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JANUARY 1961

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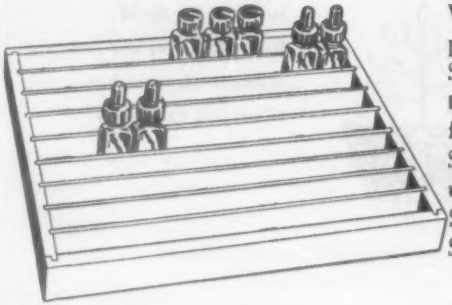

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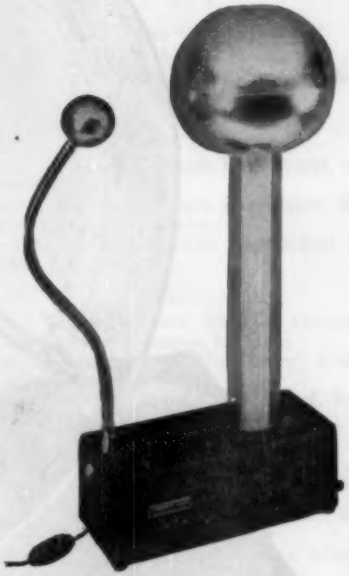

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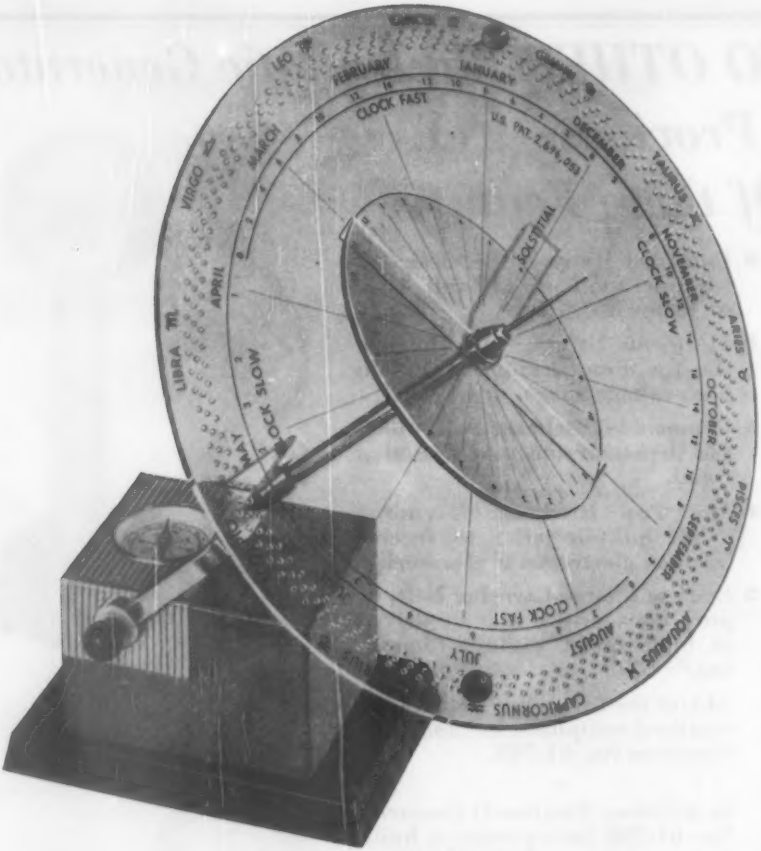

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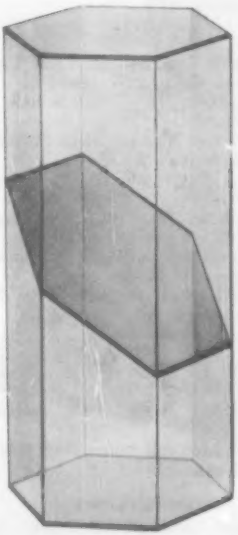

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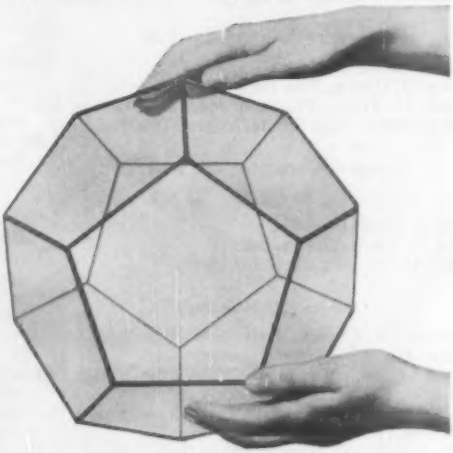

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A Brief History of Statistics: A Contribution for the Enrichment of High School Mathematics

Thomas L. Stringfellow and Emma L. Stringfellow
501 Courthouse, Shreveport, Louisiana

Statistical analysis and its companion, probability, are topics that are found to be intriguing when introduced as enrichment in modern high school mathematics courses. Since such topics are among those introduced as "modern" and "new" many high school pupils are surprised to learn that statistics as a functional process dates back into antiquity and that with the clarification brought about by studies in probability became a mathematical theory in the sixteenth century. The history of how the present theory of statistics evolved is of interest, primarily to high school pupils who have studied the fundamentals of the topic or to those who may have used some of the elements of statistics as tools in science or the social studies.

The word "statistics" comes from the Italian word "statista" which in turn was derived from the Latin "status" meaning state. While the word itself was not used until the eighteenth century (by Gottfried Achenwall) statistical facts relating to population, taxes, births, and wealth, were gathered by the Chinese as early as 2300 B.C., and by the Egyptians in 3050 B.C. while building the pyramids. The Book of Numbers records the taking of the census of the Israelites on two occasions. One of the kings of Babylon is credited with having instigated the system of decades of numbers by calling for a count of able-bodied fighting men in his kingdom. The Romans

excelled all other nations in keeping records of births and deaths and of making surveys of the entire empire.

The Influence of Probability

Most of the science of statistics is based on the theory of probability. The transition of statistics from a function tool to being a science dates from the seventeenth century when Chevalier de Mere, a gambler, asked two mathematicians questions concerning the division of stakes between two players who separated without completing their game. Even as far back as 3500 B.C. gambling with and without dice was practiced. However, due to superstition and the influence of the church, gambling questions had not been contemplated by scholars. From de Mere's problem, the two mathematicians, Blaise Pascal and Pierre de Fermat formulated the basic theory of probability. Three years after this date (1654) Christian Huygens wrote the first book concerning the chances of winning certain card and dice games. Upon reading this gamblers' manual, three men, Jacques Bernoulli, Pierre Montmart, and Abraham Demoivre, moved the theory into the realm of statistics by applying the theory of probability to such problems as the chance of a person dying within one year and the chances that an unborn child would be a boy. In 1662 John Graunt showed how to combine the register of deaths in London and the theory of probability to make forecasts of population trends.

Introduction of the Components of Statistics

The theory of statistics as we use it today is made of components originated by different scientists working in England, France, Germany, and Italy. The idea of the *normal curve* which makes possible a more precise definition of the *average* or *mean* emerged from a formula worked out by Demoivre. The origin of the term *average* derived from a word used in maritime circles to describe extra charges on freight.

In 1778 Pierre-Simon Marque de Laplace found that his newly formulated law of errors fell into a curve resembling the normal curve. His discovery was further validated by two astronomers, Fredrick Bessel and Carl Gauss, Gauss later contributed a method by which the *probability of error* in an observation could be calculated. He named this method the formula of *least squares* and Bessel proposed the term, *probable error*. In 1832 Johann Encke, a student of Gauss, published a formula for finding the error of a mean and a *standard deviation*.

The extension of statistical formulas to many fields was promoted by a philosopher-astronomer-mathematician, Adolphe Quetelet. This versatile man was a member of more than one hundred learned soci-

eties during his lifetime. He organized a Central Commission of Statistics in Brussels which served as a pattern for census bureaus of other nations. The London Statistical Society and the first International Statistical Congress were both organized under his guidance. In this organization effort, Quetelet proposed a list of forty topics worthy of being investigated by the statistical methods. These topics were grouped into the general headings of meteorology, physics, chemistry, botany, zoology, agriculture, and man. His enthusiasm for statistical analysis was contagious and his influence infected admirers in all fields of endeavor. His work in anthropology, specifically the influence of age, sex, education, climate, and seasons on criminal tendencies further pushed back the frontier of science for the use of statistics.

The English scientist, Sir Francis Galton, became interested in statistics as a tool for use in his favorite topic of investigation, the inheritance of intelligence. This application of the known formulas resulted in the coming of some new terms: *percentiles*, or groups of data on the normal curve, a *cumulative record* or record of a pupil's physical and mental examination that followed the pupil throughout his school life, and the term *regression* which clarified the formula for correlations. (Galton introduced the use of "r" to indicate *coefficient of correlation.*) Galton's works with measurement of heredity laid the groundwork for the modern science, biometry.

The next important work on statistics had the University College, London, as its setting. Professor Karl Pearson became interested in the writing of Galton, and struck by the lack of data needed to verify some of Galton's hypotheses, undertook problems concerning such points as stature, size, fertility, and longevity of man, coat color of thoroughbred horses, and wing markings of moths. Using these biological data in testing and verifying statistical formulas involved Pearson in a number of bitter disputes with other professors and students and established his reputation as a dour man as well as an expert statistician. Some of his accomplishments are extensive statistical tables (*table of complete beta function*) theory of chi-square, theory of the *coefficient of contingency*, *mean*, *error*, *mode*, *partial correlation*, and *standard deviation*.

Pearson had a large number of students during his career at University College. Many of his students were involved in the computations and proof of the various theories attributed to Pearson. It has been said that he considered his department a research activity and not a lecture-learning department. Among these research students was William Sealy Gossett who did extensive research in applications of statistics to agriculture. It is not known the degree to which Pear-

son received credit for work done by this student, but whether to protect his discoveries from being claimed by Pearson or whether he simply desired anonymity. Gossett assumed the pseudonym "Student" for all of his contributions to statistics. The formulas which he contributed that are most helpful today are the *T* and *Z* lists, *probable error* of a *mean* and a *correlation coefficient.*

Statistics as a Formal Discipline

From its beginning as a functional tool for matters of state, statistics had to wait several hundred years before it gained status as a formal discipline or subject in a college curriculum. The first course in an American university was offered at Columbia University in 1880. This was in the field of political science. In 1887 statistics of psychology and in 1889 statistics of anthropology were offered in Columbia. In 1897 biological statistics was taught by Charles B. Davenport at Harvard College. Davenport's book *Statistical Methods in Biological Variations* was the first textbook on statistics to appear in America. At the same period work at University College in London, and pioneer work in other European colleges was being done under dedicated teachers and experimentalists.

In the first half of the twentieth century, statistics as a method has been applied to every branch of science, the social studies and education courses are offered in every college and university. Research workers regard statistics as their most important tool for organizing data and for removing the guess-work from experimental findings.

NEW TEACHING METHODS URGED FOR CREATIVE CHILD

Teachers may have to adapt present methods of instruction to recognize and meet the demands of the imaginative, creative child, a University of Chicago educator said.

The "creativity quotient" of the child must be measured as well as his intelligence quotient, Prof. J. W. Getzels stated at a news conference with Lawrence G. Derthick, U. S. Commissioner of Education. Tests that will show this ability should be devised, he said.

Dr. Derthick noted that we "may be losing as much as 70% of these gifted, creative children" by failure to recognize them in the homes as well as in schools.

The Commissioner called the news conference to report on progress made in research on gifted and superior children sponsored by the U. S. Department of Health, Education, and Welfare. He predicted that educational changes in the next ten years as a consequence of current findings would be far greater than those that have occurred in our history.

Creative abilities show a sharp drop in the fourth grade, it was reported. This fourth grade slump is born out by continuing surveys over the past several years by Science Service of science interests of students.

Fermat's Principle of Least Time and Snell's Law of Refraction of Light

J. O. Perrine

36 Marion Road, Upper Montclair, New Jersey

In high school and college physics classes, the refraction of light elicits interest and arouses curiosity. By use of a tumbler of water, a glass block, glass prisms and lenses, the simple and basic phenomena of the bending of light rays, as they pass from one transparent medium to another medium of different optical density, are readily shown experimentally. Real and virtual images as they are produced because of refraction by lenses make attractive demonstrations on the part of the instructor and engaging laboratory experiments on the part of the student.

Snell's Law of Refractions states that the sine of the angle of incidence of a light ray divided by the sine of the angle of refraction is equal to the index of refraction. Furthermore, Snell's Law states that the index of refraction is equal to the ratio of the velocities of light in the two media.

The accompanying drawing, Figure 1, portrays the phenomenon and the factors and relations involved.

In discussing the concept of velocity as it is involved in refraction, the instructor points out that of all substances, the index of refraction of the gem or jewel called a diamond has the largest numerical value; namely 2.5. This means that for some reason or another, light elects to travel slower through crystallized carbon than through any other substance. In other words, light travels 2.5 times faster in air than through a diamond. As illustrated in Figure 1, light travels 1.3 faster in air than in water.

Principle of Least Time

About three hundred years ago, Pierre Fermat (1601–1665) propounded the interesting idea than when light travels from a point in an optically rare medium with a given light velocity to a point in an optically denser medium in which the light travels slower, or vice versa, the light takes such a path as to make the journey in the least possible time.

In Figure 1, this means that light from S to R to F or from F to R to S takes that particular path so as to complete the journey in the least possible time, considering the basic fact that light travels 4/3 faster in air than water.

In proposing this simple and basic truth, Fermat showed mathematically that if the ray of light did choose to travel a particular path in the least possible time, then interestingly the paths would be

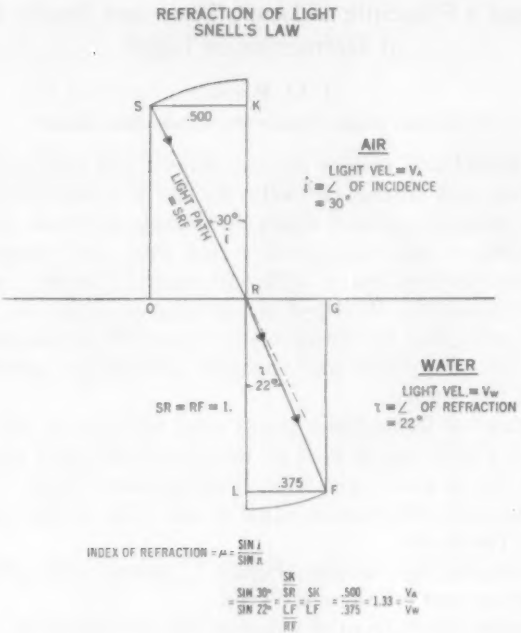

FIG. 1

such that Snell's Law would be a logical concomitant and consequence.

This mathematical analysis is given in last pages of this article.

A Specific Illustration and Implementation of Fermat's Principle

It is the purpose of this paper to illustrate and implement realistically the relation of Fermat's Principle and Snell's Law. The relationship of the two laws is beautifully rationalized by a simple application of the differential calculus in a formal way. However, the formal mathematical proof can be implemented by analysis of a particular case by numerical calculations and curves relating to several possible paths.

Assume by way of analogy, there is an orchard and a ploughed field on a farm. As per Figure 2, a son is at point S in the orchard and the father is at point F in an adjoining ploughed field. The line JJ' is the dividing line between orchard and ploughed field. Further assume that the father has had an accident due to some mishap with a tractor and is hurt. He shouts for help. The son hears the call for help and of course wants to reach his father in the least possible time.

In such a situation, the theoretical path to be taken by the son running to his father would depend on several different factors all of which would be different under a generalized analysis. As shown in the particular case of Figure 2, first assume the boy can run 20 feet per second in the firm earth of the orchard and 10 feet per second in the loose earth of the recently ploughed field. As portrayed in Figure 2, the distance *SO* (or *a*) is 50 feet; the distance *GF* (or *b*) is 200 feet and the distance *OG* (or *p*) is 500 feet. As stated above, there would be a great number of possible situations that might exist, that is the distances *a*, *b* and *p* could be a variety of distances. Just what numerical values of *a*, *b* and *p* prevailed would determine the particular path to take to reach his father in the least possible time.

If the boy, who had studied physics, did know his two running velocities and the distances involved, it would be out of the question to know at a moment of reflection just how to run. The boy might remember that his angle of incidence and his angle of refraction had a relation to the sine of his angle of incidence and the sine of his angle of refraction and the ratio of his running speeds. But what to do about it would not be possible to determine at once. About the

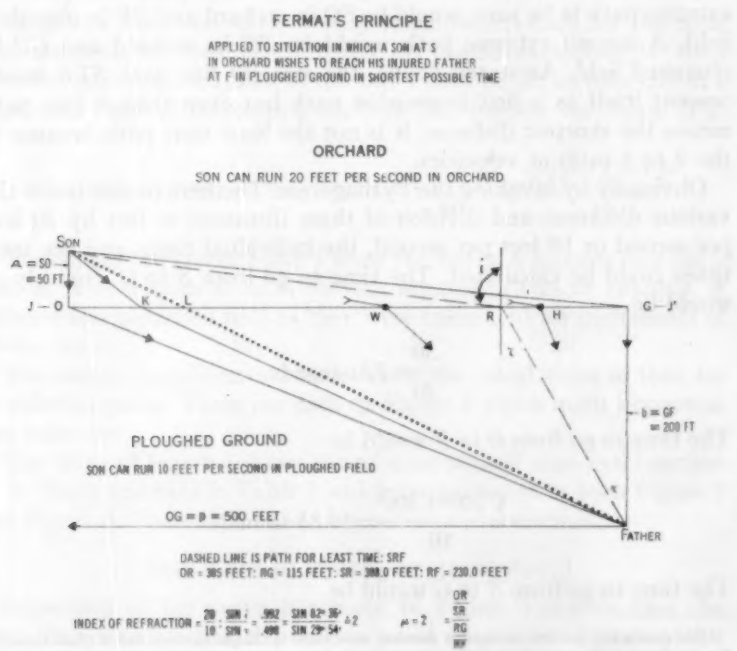
FERMAT'S PRINCIPLE
APPLIED TO SITUATION IN WHICH A SON AT S
IN ORCHARD WISHES TO REACH HIS INJURED FATHER
AT F IN PLOUGHED GROUND IN SHORTEST POSSIBLE TIME
ORCHARD
SON CAN RUN 20 FEET PER SECOND IN ORCHARD
SON
A = SO = 50 FT
J — O
K
L
W
R
H
G — J'
i
r
b = GF = 200 FT
PLOUGHED GROUND
SON CAN RUN 10 FEET PER SECOND IN PLOUGHED FIELD
OG = p = 500 FEET
FATHER
DASHED LINE IS PATH FOR LEAST TIME: SRF
OR = 385 FEET: RG = 115 FEET: SR = 388.0 FEET: RF = 230.0 FEET
INDEX OF REFRACTION = 20/10 : SIN i / SIN r = .992/.498 = SIN 82° 36' / SIN 29° 54' ≐ 2
μ = 2 = OR/SR / RG/RF

FIG. 2

only fact that the boy could capitalize on as a result of studying physics would be that when a ray of light passes from a fast to a slow medium, the ray of light bends toward the perpendicular drawn at the point of change of direction. So in a flash of thinking, the boy reflects, I do not want to take the straight line *SLF*. It is the shortest distance to be sure but surely not the path of shortest time. I sure do not want to take path *SKF* in which case I would be bending away from the perpendicular. If the boy did consider path *SGF* he as a young student in physics might realize his angle of refraction would be zero degrees. Such angles of refraction are extraordinary. So the boy elects to run diagonally toward the border line JJ' to some point somewhere between L and G, preferably a bit nearer G than to L. He would thus, under any path, run along a path which would bend toward the perpendicular.

Calculations*

In analyzing and calculating the various possibilities in the specific case (Figure 2) assumed in order to illustrate and implement the meaning and the significance of Fermat's Principle, assume a variety of paths and calculate the varying times for each path. One path, an extreme path to be sure, would be SO in orchard and OF in ploughed field. A second extreme path would be *SG* in orchard and *GF* in ploughed field. As stated above, the straight line path *SLF* would present itself as a first impression path but even though this path means the shortest distance, it is not the least time path because of the 2 to 1 ratio of velocities.

Obviously by invoking the Pythagorean Theorem to determine the various distances and division of these distances in feet by 20 feet per second or 10 feet per second, the individual times and the total times could be calculated. The time to go from S to O, (namely a) would be

$$\frac{50}{20} = 2.5 \text{ seconds.}$$

The time to go from O to F would be

$$\frac{\sqrt{500^2+500^2}}{10} = 53.85 \text{ seconds.}$$

The time to go from S to G would be

* The curves and the 100 calculations therefore were made by Ralph Jacobson and William Labanche, Physics Majors at Montclair State College, Montclair, N. J.

$$\frac{\sqrt{50^2+500^2}}{20}=25.12 \text{ seconds.}$$

The time to go from G to F would be

$$\frac{200}{10}=20 \text{ seconds.}$$

The value of X for equal distance paths in orchard and ploughed field can readily be found by solving for X in equation

$$50+X^2=200^2+(500-X)^2.$$

X comes out to be 287.5 feet. Therefore the equal distance paths are

$$\sqrt{50^2+287.5^2} \quad \text{and} \quad \sqrt{200^2+212.5^2}.$$

The equal distance paths are 291.82 feet.

Generalized Equation for Total Time

In general, one can write readily a simple equation for the total time necessary for the different paths. Let the distance along JJ' from O to the point of refraction of the boy's path be X, namely OK in a particular case. X increases from 0 to 500, namely the value of p.

$$\text{Total Time}=SUM \text{ of Two Times}=\frac{\sqrt{a^2+X^2}}{20}+\frac{\sqrt{(p-X)^2+b^2}}{10}.$$

The curves of Figures 3 and 4 show the times in seconds as a function of X feet from O to G for the separate times of running in orchard and ploughed field as they were calculated for increments of 10 feet for X.

This means that Figures 3 and 4 show the calculations of time for 50 different paths. There are data on Figure 3 which merit inspection and reflection.

The curve of Figure 4 shows the relation of total time as a function of X. There are data in Table I which are pertinent to both Figure 3 and Figure 4. These data merit inspection and reflection.

Least Time as Portrayed in Figure 4

Inspection of the curve portrayed in Figure 4 reveals that the least time, identified at the bottom point or point of flexure of the curve, occurred at $X=385$ feet. The least time is 42.4 seconds.

CURVES SHOWING INDIVIDUAL TIMES IN SECONDS OF RUNNING IN ORCHARD (T_O) AND IN PLOUGHED FIELD (T_P) AS RELATED TO X

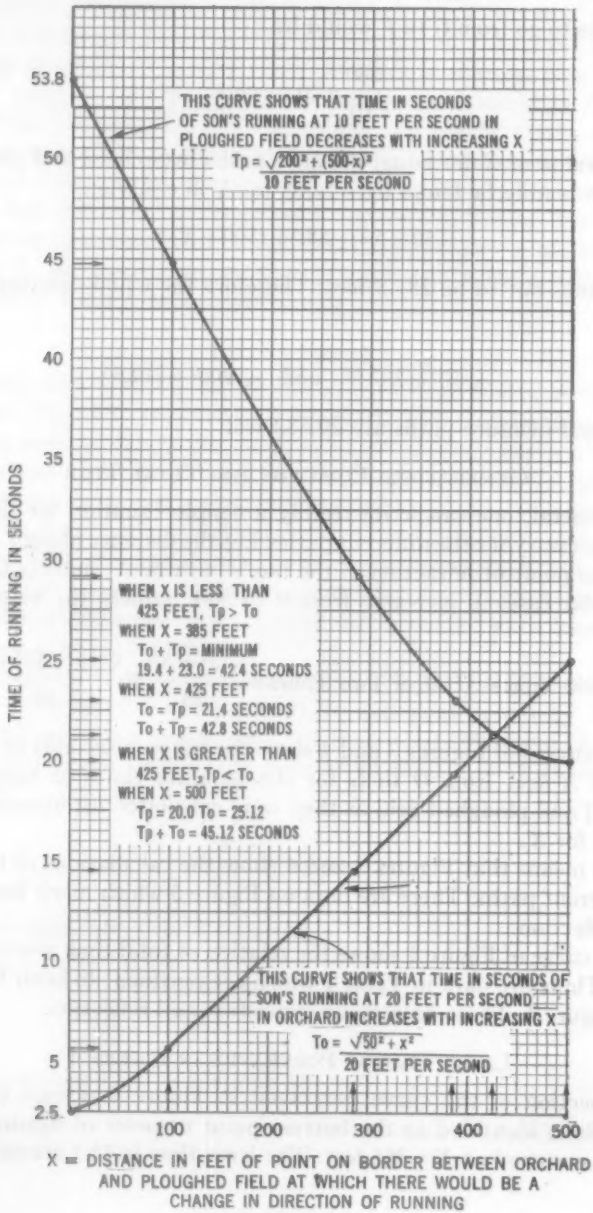
53.8
50
45
40
35
30
25
20
15
10
5
2.5
TIME OF RUNNING IN SECONDS
THIS CURVE SHOWS THAT TIME IN SECONDS OF SON'S RUNNING AT 10 FEET PER SECOND IN PLOUGHED FIELD DECREASES WITH INCREASING X
Tp = √(200² + (500-x)²) / 10 FEET PER SECOND
WHEN X IS LESS THAN 425 FEET, Tp > To
WHEN X = 385 FEET
To + Tp = MINIMUM
19.4 + 23.0 = 42.4 SECONDS
WHEN X = 425 FEET
To = Tp = 21.4 SECONDS
To + Tp = 42.8 SECONDS
WHEN X IS GREATER THAN 425 FEET, Tp < To
WHEN X = 500 FEET
Tp = 20.0 To = 25.12
Tp + To = 45.12 SECONDS
THIS CURVE SHOWS THAT TIME IN SECONDS OF SON'S RUNNING AT 20 FEET PER SECOND IN ORCHARD INCREASES WITH INCREASING X
To = √(50² + x²) / 20 FEET PER SECOND
100
200
300
400
500
X = DISTANCE IN FEET OF POINT ON BORDER BETWEEN ORCHARD AND PLOUGHED FIELD AT WHICH THERE WOULD BE A CHANGE IN DIRECTION OF RUNNING

FIG. 3

Calculation of Sines

With the many numerical calculations providing the curve of Figure 4, the fact is revealed that the path of least time is that of the dashed line in Figure 2, in which $X = 385$ feet. We know that the tangent of angle of incidence (i)

$$(\angle OSR) = \frac{385}{50} = \frac{OR}{OS} = 7.70.$$

CURVE SHOWING TOTAL TIME OF TRAVEL VIA VARIOUS PATHS FROM A GIVEN POINT IN ORCHARD TO A GIVEN POINT IN PLOUGHED FIELD

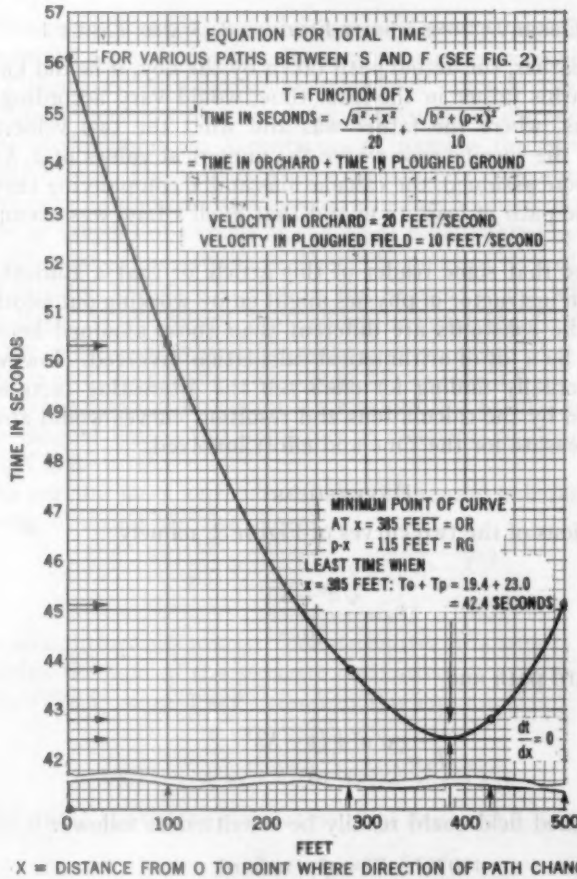

Fig. 4

Consulting a table of sines and tangents, it is revealed that the angle whose tangent is 7.70 is 82° 36′. In turn, the sine of the angle of incidence (82° 36′) is .992. Likewise the tangent of the angle of refraction (r) ($\angle RFG$) is

$$\frac{115}{200}=.575.$$

The angle if 29° 54′. In turn the sine of 29° 54′ is .498.

So as was to be illustrated

$$\frac{\sin i}{\sin r}=\frac{.992}{.498}\doteq 2. \qquad \text{Of course } \frac{V_0}{W_P}=2.$$

Some Observations about Figures 2, 3 and Table 1

As stated earlier, the actual path taken by the boy, if he did know how to reach his father in the least time, would vary according to where he was, where the father was and what the two velocities were. But in the specific case where the numerical values of a, b, p, V_o and W_p were assumed, the calculations and accompanying curves did reveal the path of least time and that Snell's Law was exemplified.

It might be that some reader of this article or that a student or students of an instructor in physics might enjoy working out another case where the constants are different than those assumed herein. There would be a lot of arithmetical calculation involved. However, the fun of actually finding for one's self the interesting facts and ideas revealed by the calculations and resultant curves would abundantly compensate for the time and effort involved.

Hyperbolas

The equations of the two curves of Figure 2, namely

$$T_0=\frac{\sqrt{a^2+X^2}}{20}$$

for the orchard path and

$$T_p=\frac{\sqrt{a^2+(p-X)^2}}{10}$$

for the ploughed field could readily be rewritten as follows:

$$400T_0^2-X^2=a^2\text{: Orchard}$$

$$100T_p^2-(p-X)^2=a^2\text{: Ploughed Field.}$$

It is observed that these are equations of hyperbolas. It is to be noted that the curves of Figure 3 definitely looks like parts of hyperbolas. It is noted that the curve of Figure 4 looks like an hyperbola too but of course it is not. It has its own equation but its equation is not the equation of an hyperbola.

Generalized Association of Fermat's Principle and Snell's Law Provided by Invoking a Basic Fact of Differential Calculus

The equation for total time as portrayed by curve of Figure 4, is

$$T=\frac{\sqrt{a^2+X^2}}{V}+\frac{\sqrt{b^2+(p-X)^2}}{V'}.$$

The curve is of no particular category. It dips rapidly as it starts downward at the upper left. Its negative steepness or slope decreases as X increases. At a particular value of X, namely 385 as observed, the curve becomes horizontal for a very short distance. It has no slope at this point. As X continues to increase, the curve acquires a positive slope. The positive slope increases as X continues to increase.

As per the doctrine and language of the differential calculus, the slope or tangent of a curve at any point is designated by dy/dX. This dy/dX is called the derivative. From the point of view of the differential calculus, the dy/dX, that is, the slope at upper left is negative and large. As one moves down along the curve the dy/dX decreases. At the point of flexure of the curve, namely where $X=385$ feet, the slope is zero. As per the language of calculus $dy/dX=0$. The tangent line to the curve at this point is a straight line parallel to the X axis. The tangent line at this point has no steepness or slope. Again, the dy/dX is 0.

As per the facts and rules of the differential calculus, the determining of dy/dX for the curve

$$T=\frac{\sqrt{a^2+X^2}}{V}+\frac{\sqrt{b^2+(p-X)^2}}{V'}$$

is a straightforward matter. The derivative of a sum is according to calculus the sum of the separate derivatives

So dT/dX, since $Y=T$ (time) in this equation

$$=\frac{X}{V\sqrt{a^2+X^2}}-\frac{p-X}{V'\sqrt{b^2+(p-X)^2}}.$$

As stated above, the slope at point of flexure is 0, so one can write

$$\frac{X}{V\sqrt{a^2+X^2}}=\frac{p-X}{V'\sqrt{b^2+(p-X)^2}}.$$

It follows that

$$\frac{V}{V_1}=\frac{\dfrac{X}{\sqrt{a^2+X^2}}}{\dfrac{p-X}{\sqrt{b^2+(p-X)^2}}}.$$

TABLE 1. DISTANCES AND TIMES FOR RUNNING IN SPECIAL PATHS INDICATED IN FIGURE 2

Path	Feet X	Feet $p-X$	Feet Orchard Distance	Feet Pl'd Field Distance	Feet Total Distance	Sec'ds T_0	Sec'ds T_p	Sec'ds Total Time	
SOF	0	500	50	538.5	588.5	2.5	53.85	56.35	Longest Time Path
SLF	100	400	111.8	447.2	559.0	5.59	44.72	50.31	Straight Shortest Path
SWF	287.5	212.5	291.82	291.82	589.72	14.59	29.18	43.77	Equal Distance Path
SRF See Fig. 4	385	115	388.0	230.0	618.0	19.4	23.0	42.4	Least Time Path
SHF	425	175	428.0	214.0	642.0	21.4	21.4	42.8	Equal Time Path
SGF	500	0	502.4	200.0	702.4	25.12	20.00	45.12	Longest Distance Path

Looking at Figure 2, one observes that

$$\frac{X}{\sqrt{a^2+X^2}}=\text{sine}\angle OSR=\sin i$$

and

$$\frac{p-X}{\sqrt{b^2+(p-X)^2}}=\text{sine}\angle RFG=\sin r.$$

So

$$\frac{V}{V'}=\text{ratio of velocities}=\frac{\sin i}{\sin r}=\text{index of refraction}=u.$$

These last equalities are a statement of Snell's Law. So whatever the numerical values of a, b, p, V and V', the light ray, of many light rays that could go, will go from any point in an optically rare medium to a given point in an optically denser medium according to doctrine enunciated in Snell's Law. This means that Snell's Law is a natural concomitant and associate of Fermat's Principle of Least Time. With Fermat's Principle as a major premise, one might say that Snell's Law has been derived and validated theoretically by the use of the simple rules, and procedures of the differential calculus.

The Fraction Equals One

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All of us remember the difficulty we experienced when, as teen-agers, we learned to use the metric system. Did one divide by 100 centimeters or did one multiply by 100 centimeters to make the answer read meters? Grade school arithmetic never seemed to daunt us, but this metric system!

Our high school chemistry and physics students are experiencing the same difficulties we had, and we should make every effort to clarify the process for them. Why not teach them that, to change from one unit in a system to another, all we need do, is multiply by a fraction *equal to one?* For example, given the problem: convert 323 centimeters to meters and then to kilometers.

$$323 \text{ cm.} \times \frac{1 \text{ m.}}{100 \text{ cm.}} = 3.23 \text{ m.}$$

$$323 \text{ cm.} \times \frac{1 \text{ m.}}{100 \text{ cm.}} \times \frac{1 \text{ km.}}{1000 \text{ m.}} = 0.00323 \text{ km.}$$

The secret of easy transposition from one unit to another lies in three steps:

a. make all numbers concrete by expressing the units of measure,
b. know the relationship of units to one another,
c. make the numerator of the conversion factor be the unit desired for the answer.

This method of converting units is especially useful in physics where the student can be overwhelmed by the abundance of units: grams, dynes, newtons, ergs, joules, watts, horsepower! As an example of a physics problem: what force in newtons is needed to elevate 50 kilograms above a table? In solving such a problem, the pertinent formula is first written and the values substituted.

$$F = m\,g$$

$$= 50 \text{ kg.} \times \frac{9.8 \text{ m.}}{\text{sec.}^2} \times \frac{1 \text{ nt.}}{\text{kg. m./sec.}^2} = 490 \text{ nts.}$$

If the force were to be expressed in dynes:

$$= 50 \text{ kg.} \times \frac{1000 \text{ g.}}{1 \text{ kg.}} \times \frac{980 \text{ cm.}}{\text{sec.}^2} \times \frac{1 \text{ dyne}}{1 \text{ g. cm./sec.}^2} = 49{,}000{,}000 \text{ dynes.}$$

As an example of a still more complicated problem which could

defeat the student unless he understands thoroughly the conversion of units, we might give the following: what horsepower engine is required to lift 200 tons of coal per hour from a depth of 400 feet?

$$P=\frac{F\ s}{t}\times\frac{1\text{ h.p.}}{550\text{ ft. lb./sec.}}$$

$$=\frac{200\text{ tn.}\times 2000\text{ lb./tn.}\times 400\text{ ft.}}{1\text{ hr.}\times 60\text{ min./hr.}\times 60\text{ sec./min.}}\times\frac{1\text{ h.p.}}{550\text{ ft. lb./sec.}}=80.8\text{ h.p.}$$

The unit method of solving problems will carry over into the quantitative $\frac{3}{2}$ solution of chemical equations. Traditionally, the high school student has been taught to solve these problems by ratio and proportion, which method tells him nothing about the chemical process. By the time the student is ready to solve quantitative chemical relationships, he is able to write balanced chemical equations. An equation tells us the mole relationships of the substances involved in the reaction. For example: if 100 grams of potassium chlorate are used to prepare oxygen, what weight of oxygen will be obtained? The student writes the equation for the reaction.

$$2\ KClO_3\rightarrow 2\ KCl+3O_2$$

By inspection he sees that the number of moles of oxygen prepared is always $\frac{3}{2}$ the number of moles of potassium chlorate. The first step in solving the problem will be to determine how many moles of potassium chlorate are being used. To do this, he uses the unit method to convert the 100 grams of potassium chlorate to moles:

$$100\text{ g. }KClO_3\times\frac{1\text{ mole }KClO_3}{122.5\text{ g. }KClO_3}=0.8\text{ moles }KClO_3.$$

Therefore, the number of moles of oxygen prepared will be $\frac{3}{2}$ this number of moles, or

$$0.8\text{ moles }KClO_3\times\frac{3\text{ moles }O_2}{2\text{ moles }KClO_3}=1.2\text{ moles }O_2.$$

After determining the number of moles of oxygen, the next step will be to convert the moles to grams of oxygen:

$$1.2\text{ moles }O_2\times\frac{32\text{ g. }O_2}{1\text{ mole }O_2}=38.4\text{ g. of }O_2.$$

After some practice, the student will be able to express the entire problem in one equation:

$$100\text{ g. }KClO_3\times\frac{1\text{ mole }KClO_3}{122.5\text{ g. }KClO_3}\times\frac{3\text{ mole }O_2}{2\text{ mole }KClO_3}\times\frac{32\text{ g. }O_2}{1\text{ mole }O_2}=38.4\text{ g. }O_2.$$

If the above problem called for the answer expressed in liters of oxygen, the solution would be just as simple. The student knows that one mole of any gas at STP occupies 22.4 liters. Therefore, the number of moles of oxygen can be converted to liters by the equation:

$$1.2 \text{ moles } O_2 \times \frac{22.4 \text{ liters}}{1 \text{ mole } O_2} = 26.8 \text{ liters } O_2.$$

In using the mole method in solving quantitative relationships, the student uses and understands a real chemical concept. He does not perform a mathematical operation for which he has no explanation. Likewise, in using concrete mathematical expressions and the unity conversion factor, he understands why certain concepts are expressed in particular units and the relationship between these units.

EVOLUTION LOSES ENZYME, MAN CANNOT MAKE VITAMIN C

Somewhere along the path of evolution between rabbits and man, a particular liver enzyme disappeared. Loss of this enzyme is the reason man is unable to manufacture vitamin C within his own body, a team of researchers from India reported.

They state that the chemical conversion of sugar to vitamin C (L-ascorbic acid) in animals is completed only when the enzyme L-gulono-oxidase is present.

In amphibians, reptiles and a number of birds, this enzyme is found within the minute particles (microsomes) embedded in kidney cells. But in other birds and in those mammals capable of manufacturing vitamin C, the enzyme has moved to the liver cells. Finally, in the higher mammals, and in at least one bird, the enzyme disappears completely.

All this indicates, the researchers state, that "in the evolutionary ascent," the enzyme originally residing in the kidney gradually passes into the liver and finally by genetic defect, disappears from the liver also.

FLUORESCENT ENZYMES HELP BACTERIA MAKE FOOD

Two substances that show up as eric, blue fluorescent lights inside living bacteria are involved in helping these tiny plants change carbon dioxide to food. The discovery brings researchers one step closer to solving the mystery of photosynthesis.

Dr. John M. Olson of Brandeis University, Waltham, Mass., reported that in certain bacteria the two chemicals which help "drive photosynthesis" are pyridine nucleotides known as DPN and TPN. DPN is diphosphopyridine nucleotide and TPN is triphosphopyridine nucleotide.

The purple bacteria contain a chlorophyll which is active in the presence of far-red light of 8,000 to 9,000 angstroms wavelength, invisible to the human eye. When the bacteria are receiving none of this red light, the DPN and TPN show a blue fluorescence of relatively weak intensity. When the red light is beamed at the bacteria, the intensity of the blue fluorescence increases. Gradually, after a red light is switched off, the brightness of the blue dims again.

The changes in intensity, it is believed, indicate that the carbon dioxide is being "fixed" or reduced to food by the chemicals, which are enzymes.

What Is the Longitude of Your City? An Historical Note

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We are so accustomed to the use of latitude and longitude that the possibility of more than one answer to the question used as a title for this note seems at first absurd. It may well be that the individual asked the question does not have the answer at the "tip of his tongue" but certainly standard references would give the answer. For example, Los Angeles is given as 118°15′W; Rio de Janeiro as 43°9′W; New Orleans 88°30′W; New York 73°W; Helsinki 28°35′E; Suez 32°33′E. It is recognized that these are approximate values. That other values could exist seems almost unbelievable.

It is less well known that for many years national pride demanded that the maps issued by a particular nation make use of longitude as measured from some principal city of that nation. For example, French maps used longitude measured from Paris, Portuguese maps made use of longitude as measured from Lisbon, English maps longitude measured from London (technically, from the astronomical observatory at Greenwich—essentially at London). In the United States of America use was made of longitude measured from Washington, D. C.

Knowledge of this fact will partially explain why certain state boundaries which are other than rivers, mountain ranges, or similar natural features, appear to have been drawn at purely arbitrary or whimsical positions. A particular example is the eastern boundaries of Nevada and of Utah. These lines seem to be placed at a purely arbitrary position, and there at first thought seems to be no reason why they should have not been moved either east or west. This, if done, would place the boundaries on a parallel of longitude an integral number of degrees from Greenwich. But when these state boundaries were established, maps of the United States were still using longitude as measured from Washington, D. C. Hence the eastern boundary for Nevada is the meridian 38 degrees west of Washington, which lies roughly four miles from the 114th meridian west of Greenwich. The boundary for Utah is the meridian 32 degrees from Washington.

It appears therefore that there is (or at least has been in the past) more than one answer to the question.

References

Utah, by J. Cecil Alter (American Historical Society, Chicago, 1932).
Nevada, by Effie Mona Mack (Arthur H. Clark Co., Glendale, Calif., 1936).

The Principle-Unit-Project Method of Teaching

L. M. Colyer

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The unit method of teaching is not new as educators have used the plan in other fields. However, the writer has developed a modified version of this plan, called the Principle-Unit-Project Method.[1] He has used this method in high school and college teaching and has found it to be very successful. Since the report of his findings, others have used it and found it to be highly satisfactory. Students who have been taught by this plan have succeeded very well in other colleges and dental, pharmaceutical, and medical schools. The method may be used for teaching any of the sciences. However, for illustrative purposes, a course in general biology at the high school level will be used.

Many of our textbooks have unit plans in them. The teacher who uses them may or may not understand why they were written as they were and what the author had in mind when he was developing the unit. As a result of this, the teacher may teach for memorization of detail and overlook the broad scope of the discipline. Moreover, this type of unit is very narrow in scope as it confines the student's training and often the teacher's learning to one textbook, which may have only one author.

For a number of years, there has been a controversy over teacher prepared units and commercially prepared units. In general, the commercial units are very "wooden" while the teacher prepared units are more flexible. Perhaps these are better than the commercial types because they may be more easily adjusted to the needs of the class. Some educators have contended that a commercially prepared unit is better for a poorly prepared teacher while a teacher prepared unit is best for a better prepared teacher. This article does not attempt to answer such questions but is designed to acquaint the reader with the Principle-Unit-Project Method.

The Principle-Unit-Project Method has a pattern which is designed to include many of the basic theories in psychology and philosophy. It embodies such psychological theories as Pragmatism, Gestaltism Goal-Insight, Phenomenal Field, and Thorndike's laws of learning. The philosophical structure of the method employs the democratic ideology. In some measure, it takes care of abilities, creates, stimulates, and provides an outlet for interest, helps to formulate scientific attitudes, and allows for discovery which is vital to interest. It com-

[1] Luther M. Colyer. "A Comparison of Two Methods of Teaching Biology at the College Level." *Science Education*, 44 (Feb., 1960) 52–58.

bines both theories of student-centered activities and teacher-directed activities. The Principle-Unit ideas will be explained first followed by the Project concept. However, they are not to be separated in practice.

Before attempting to explain the method, let us examine a textbook to see how it is written. The author, before constructing his outline, decides upon the subject and its approach. Following the selection of unit titles, the chapter titles are chosen. These are in general form and may be revised; however, they do serve as guides. Principles are chosen for the development of the chapters and then detailed information is selected to explain and illustrate them. This plan has become so universal that many authors have included the word principles in the title of their textbooks, e.g.,

Principles of Immunology, Cushing and Campbell, McGraw-Hill, New York, 1957.
Principles and Problems of Botany, Sennott and Wilson, McGraw-Hill, New York, 1955.
Integrated Principles of Zoology, C. P. Hickman, D. V. Mosby and Company, St. Louis, 1959.
Essentials of Human Embryology, Frank Allan, Oxford University Press, New York, 1960.
Principles of Biology, W. G. Whaley *et al.*, Harper Brothers, New York, 1958.

In almost every field of science, research has been carried out to find the basic principles which underlie the study. Also, it is realized by educators that if students are to advance far into the field of science these basic principles must be understood and mastered. The following is cited to give the reader some idea of the publication of pamphlets listing these principles.

The Major Principles of Biological Science of Importance for General Education, Edgar Martin, Department of Health, Education, and Welfare, Washington, D. C., 1956.
Principles of Physics, Harold E. Wise, Department of Health, Education, and Welfare, Washington, D. C., 1956.
Principles of Physics, Chemistry, and Geology, Ellsworth S. Obourn *et al.*, Department of Health, Education, and Welfare, Washington, D. C., 1956.
Biological Principles, William Etkin *et al.*, New York City University Press, New York, 1955. (college level)

The Principle-Unit

The Principle-Unit Method is divided as follows:

Teaching Unit

I Title
II Teacher Objectives
III Guiding Principles
IV Statement of Significance
V Student Objectives
VI Overview
  A. Points of Interest
  B. Questions for Discussion

VII Reading References
VIII Vocabulary
IX Activities
X Biological Problems
XI Remedial (Minimum) Activities
XII Advanced Student Activities
XIII Supplementary Material
XIV Evaluation of Student Progress
XV Evaluation of the Unit

Student Unit

I Title
II Guiding Principles
III Statement of Significance
IV Student Objectives
V Overview
  A. Points of Interest
  B. Questions for Discussions
VI Reading References
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VIII Activities
IX Biological Problems
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XI Advanced Student Activities
XII Evaluation of Student Progress

The Teaching Unit should be an inclusive plan which covers everything the teacher hopes to accomplish in the development of the unit. The Student Unit is for the class and should be used in their study of the unit. The use of the Student Unit will be more fully explained in the section on Methodology.

The Title

The Title of the unit should be selected before starting its outline. It may not be in its final form and perhaps will need reconstruction as the writing progresses. The Title should fit the body of knowledge to be studied, as well as indicate the approach to the study, i.e., structural or functional. It should be simple in design but the theme should be broad enough to give ample coverage of the area in mind. After the Title has been decided upon, the wording should be studied to see if it has the meaning intended and points to a definite direction of study.

Teacher Objectives

The Teacher Objectives are those goals that the teacher wants the class as a whole to attain. In order for him to guide the class in attaining these objectives, he must know something of the general nature of the students, e.g., range of interests, intelligence, abilities, aptitudes, and attitudes. These can be obtained in part from the school guidance personnel or principal and by asking the students. In addition, such information as interests, (scientific) abilities, (self ratings)

aptitudes, (hobbies) and attitudes (superstitions, dislike for plants and animals etc.) may be determined from student questionnaires filled out at the beginning of the term.

Guiding Principles

The guiding principles may be selected from Martin's[2] or Etkin's[3] list. These are broad in scope and encompass a general thought. However, they are widely recognized and need not be explained here. The principles should be few in number and serve as definite guides for the construction of the unit. In choosing material for the activities, the writer of the unit should bear in mind his guiding principles and constantly ask himself if the selected material has any connection with the selected guides. This will keep him from assimilating a mass of unrelated material. In addition, the principles may be useful in constructing and answering biological problems and in the development of essay questions.

Statement of Significance

The Statement of Significance may be selected from other sources or may be constructed by the writer of the unit. The statement should be related to the title and guiding principles and should meet the following criteria: first, it should help explain to the students why this unit of work is important; second, it should be a motivating statement, promoting inquiry and invoking discussion; third, it should be an aid in bringing about understanding of future activities. The statement should be tested carefully after the unit has been constructed to see if it meets the aforementioned criteria.

Student Objectives

The Student Objectives should be designed in part by the teacher. However, the students should have an opportunity to help decide on some of their objectives. This may be done after the Student Unit sheets have been passed out to the class. In the writer's opinion, the selection of Student Objectives should not be left solely to the class. Immaturity and the lack of knowledge hinders the students from deciding and seeing their objectives clearly. It is readily recognized that one cannot think well without some facts on which to formulate his decisions or opinions.

In reviewing the selected textbooks for Kansas it can be noted quickly that one of the books is very general in scope and vocabulary, another is somewhat more advanced, while the third is still more

[2] Edgar W. Martin, "A Determination of Principles of Biological Science Important for General Education." Unpublished doctor's dissertation, Department of Education, University of Michigan, 1944.

[3] William Etkin, *College Biology*. Thomas Crowell and Company, New York, 1950.

detailed and more advanced. In constructing a Principle-Unit the multiple textbook approach should be used. It is recognized that most classes may be divided into three groups: those who are slow, those who are average, and those who are advanced. One textbook usually serves as a basic guide. However, the person who is constructing the unit should keep his class in mind, rely on his training and judgement, his guiding principles, and his objectives in selecting material. Also, he should bear in mind other references such as college texts, encyclopedias, magazines, journals—in short, any source that will give him the coverage he desires.

In general the material should be listed as follows: name of source, author, date, chapter, and/or page numbers. The Principle-Unit writer may wish to cite the section of activities in which the article is to be used, e.g., "The Origin of Elements," William A. Fowler, *Saturday Evening Post*, (June, 1960) pp. 40–41, 66–81. This article is for Section F of the Activities. Section F may contain questions or problems that are related to this article and can only be answered by reading or studying the article.

Vocabulary

Vocabulary in any subject is vital. Every study contains words which are particularly related to that field. Not only the meanings are important, but so is the pronounciation and spelling.

The vocabulary may consist of words at the end of chapters or those selected by the writer of the unit. A more ideal way would be for the students to select their own vocabulary. This, however, usually deteriorates to the point where they have very few words in their vocabulary list or none at all. After the unit has been taught, the teacher may want to add or delete some of the words on the suggested list.

The vocabulary words may be pronounced to, and/or with the class at the beginning of the unit. The meanings may be given in short form by the teacher or the class may be left to discover the meanings as they proceed with the unit. During the teaching of the unit, the students should be urged to use the vocabulary in speaking and writing.

Overview

The primary purpose of the Overview is motivation. It should be handled from two different angles; that of the teacher and that of the students.

The first part of the Overview should contain points of interest or highlights of the unit. This should be handled from the teacher's point-of-view. Here, the teacher may use a film to help introduce the

unit, or he may lecture, give related historical facts, tell a folktale, and present a model or a demonstration. In short, he may do anything which he thinks will create interest. He should be aware that he wants to create interest at all levels of ability and that his material is related to the guiding principles, student objectives, detailed work of the unit, laboratory work, projects, and/or field trips.

The second part of the Overview should contain Questions for Discussion. They should provoke thought on the part of the students and should be related to the past work and future activities. Questions should be constructed in such a way by the teacher that they will encourage spontaneous questions from the class. To some questions no final and conclusive answers should be given, but the answers may be found as the study progresses.

The Overview should reflect the beginning of the study and indicate the nature of future activities. It should take the extrinsic learning that the teacher has constructed for the student and turn it into intrinsic learning so that there can be permanent retention.

Activities

Activities are the body of the unit. Here, information not found in the references may be given, instructions outlined, demonstrations performed (either by the student or the teacher), lectures and reports given, questions answered by the students, and certain references cited for study with no recitation or discussion. The teacher may bring in professional people for demonstrations, talks, etc.

In this area the teacher may use many methodologies. He may go into detail in a certain area while another is given general coverage. The laboratory work should be designed so that it coincides with the activities. It should be so planned that it will enlarge, enhance, and bring about a better understanding of the material. If the teacher believes that interest is sufficiently aroused in a student, a personal project may be decided upon by the student and the teacher. Here is a fine opportunity to develop the use of the scientific method.

In constructing the activities, there should be a sequential tie of guiding principles, objectives, vocabulary, biological problems, remedial activities, advanced student activities, and evaluation.

Upon completion, the unit should be reviewed as a whole for the purpose of theme continuity.

The writer of the unit should watch in constructing the activities that they don't deteriorate into a group of questions asking How, What, Why, and Where. Also, in teaching the unit he should refer to material which has been previously covered. Not only will this help to establish the subject matter in the student's mind, but it will give him some idea of its continuity.

Biological Problems

Learning is more meaningful if it can be experienced or brought within the realm of the student's experience. Practical problems should be designed so that they make the student reflect on previous activities and/or guiding principles. The writer believes that students should have practice in thinking. (So much of our education is of the memory type.) Much can be done in training the mind. Situations must arise or be created before reflective and/or critical thinking can be done. Biological problems should be written so that they will aid all students in comprehending and applying their biological knowledge. This, in part, helps to meet some of our objectives of learning.[4] The student should be allowed to write some of his own biological problems. He should write a solution of the problem citing references, activities, and/or guiding principles that aided him in arriving at his solution. The student should be made aware that he can seek outside help in solving his problem, e.g., teachers, resource persons, or other reference books not listed in the unit. The teacher should check to see if his solution is logical and has some proof of being correct.

Remedial (Minimum) Activities

These activities give a minimum coverage of the material to be covered. Since this is primarily for the slow student, it should have the simplest vocabulary and be brief in nature.

The slow student may do the regular activities or he may do only the remedial (minimum) work. This is meant to be used at the teacher's option. Also, it may be used for the average student who for some reason has missed part of the regular activities. The teacher may wish to leave it out entirely. However, it should be written into the Teaching Unit and on the Student Unit guide sheet.

The word Remedial may be changed to Minimum Activities. Students who are low or failing the course could be directed to do this section of the unit. Caution must be exercised for the teacher may be overlooking the student who needs to have his interest aroused or has other difficulties. This is a problem where the teacher can use the guidance counselor, curriculum consultant, or principal.

Advanced Student Activities

Advanced Student Activities are those which should challenge the mind of the brilliant and as such should be placed on the college level. They should consist of problems, e.g., activities calling for research which produces reflective and/or critical thinking.

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[4] Benjamin S. Bloom, *Taxonomy of Educational Objectives*, Longmans, Green and Company New York, 1954, pp. 185–192.

The teacher should demand top quality work from students attempting to do advanced activities. He should examine it for accuracy in knowledge, comprehension, and application of knowledge. Also, grammar, the use of words, and coherency should not be overlooked. Here again the teacher may call on the guidance counselor for information about certain students and/or a curriculum consultant for guidance in constructing such activities.

Supplementary Activities

Supplementary work is for the teacher's information. This section may consist of a listing of material that he will need to develop the unit. However, it could be activities that he wishes to use in the future. The materials may be marked as to their source, e.g.,

Films—Heart and Circulation—A. V. Center, College
Article—"The Development of the Heart"—*Coronet Magazine*
Models—Human Torso—Stockroom in basement

Evaluation of Student Progress

The evaluation should be of two types, objective and subjective. The objective evaluation may be a test consisting of true-false questions, completion, multiple choice, matching, vocabulary (spelling and definitions), naming parts on drawings or models, and essay.

If minimum work has been required of a student it is best to design a special objective test based on activities from the assigned work. The results should not be compared to the rest of the class but to other members of the class doing this work or to previous members who have done similar work. If the student has done minimum and regular activities, a special section of objective questions may be added to the regular test.

If some students have done the Advanced Student Activities, a special test may be designed based on these activities. These results, too, should not be compared to the rest of the class but to other members of the class doing this work or to previous members who have done similar work. The laboratory practical is of the objective type and is discussed in the section, Laboratory Work.

The subjective evaluation should consist of reports, notebooks, laboratory exercises, and projects. All subjective material should be graded good, fair, or poor and/or acceptable (complete) or unacceptable (incomplete). These evaluations should be recorded on an evaluation sheet.

Both objective and subjective grading should be considered in determining final test grades.

Laboratory Work

The Laboratory Work is a basic part of the unit. It should not be performed in isolation. Carrying out an experiment in the labora-

tory during the teaching of the same material in the classroom reinforces and helps to establish the knowledge in the minds of the students.

Planned laboratory experiments are fundamental to learning. If the teacher has planned this phase of learning it becomes purposeful and it will cover something that is vital and basic in the field. Otherwise, laboratory work drifts aimlessly, consumes much time, creates discipline problems, and wastes materials.

The laboratory sheets should be teacher prepared. However, if the teacher feels incapable, then commercially prepared laboratory sheets may be used. The teacher should have background enough so that he can design a laboratory experiment which will fit his unit. The general plan of a laboratory exercise should consist of purpose, materials, procedure, results or conclusions, and responsibility. The purpose is to explain what the laboratory exercise is supposed to accomplish. The materials should consist of equipment needed to carry out the experiment. Procedure should contain directions of what is to be done. Results or conclusions should be realized by the student. Questions and problems should be added to this part. Responsibility cites duties the student must do before leaving the laboratory.

The laboratory sheets may be kept in a notebook. However, the teacher should examine them as soon as possible for accuracy and completeness, preferably right after the experiment or at least by the end of the unit. This evaluation should be recorded on the evaluation sheet.

Practical laboratory examinations are desirable and should be given periodically. They may be given privately or on a station to station basis. The test should be designed so that the student will have little or no written work. It should consist of identification, location, naming, giving function or structure, demonstrating a technique, or explaining a reaction.

In the writer's opinion, good laboratory work is highly desirable and is considered essential to learning. If one considers Koch or some of the other great men in science, he will quickly see that they were especially careful with their laboratories and their techniques.

Methodology

The Student Unit consists of a Title, Guiding Principles, Statement of Significance, Student Objectives, Overview, Reading References, Vocabulary, Activities, Biological Problems, Remedial (Minimum) Activities, Advanced Student Activities, and Evaluation of Student Progress.

The Student Unit should serve as a study guide as it gives directions, asks questions, gives sources of information, or imparts information. In short, it is a methodology which is self-directing.

The Student Unit should speed up activities while producing greater

depth and coverage of the material. The student quite often believes that reading consists of study and fails to see logic and sequence in his studies. Also, by mere reading, the mind isn't challenged and creativity and interest are subdued.

Often in the conventional study, the individuality of a student is lost and there is little or no rapport between the teacher and student. The project part of this method should bring the two close together.

Various methodologies may be used. It is recognized that learning abilities vary greatly. Some students learn more easily under one method than another. The writer believes that certain materials can be presented more easily by one method than another. Thus, by using several methods, learning is enhanced and interest stimulated.

It is recognized that lecture is the backbone of learning, however, it is a highly overworked method. Many times it is unrelated to the material, poorly prepared, and the lecturer may have a tendency to wander off the subject. Lecture with recitation or discussion is more desirable. Demonstration, laboratory work, problems, projects, reporting, visual aid, field trips, and class discussions should be embodied within the teaching of the Principle-Unit-Project Method.

The beginner should make a methodology chart. He should cite various sections and state the methodology he plans to employ. This will give him practice in using various methods. When he has command of these, he should refine his teaching techniques. This should help the beginner to keep sight of methods and not become buried in subject matter.

The Project

The Projects may be individual or two or more students may work on one together. However, in the writer's opinion, it is more desirable to have individual projects. They may be derived from the activities, e.g., laboratory exercises, field trips, reports, or discussions. They could also develop from interests that originated outside the classroom and may be real life experiences.

The student should have a sincere interest in his project and he should discuss it with his teacher. Together they should explore its possibilities to see if it is within the range of his ability and if the necessary equipment is or can be made available.

The project should be constructed along research lines, e.g., lineal, historical, and the scientific method. If there is no plan, the project breaks down into play and the student will wander aimlessly.

A lineal type project is a continued study in which regular information is obtained. The evidence may or may not be conclusive. An example of this would be gathering weather data or data on the migration of birds.

The historical type project may constitute a research into the history of some event in science, e.g., "Vesalius and His Attempts to do Human Dissecting" or "The Discoveries of Louis Pasteur and How They Affect Modern Society."

The problematic type project should follow the outline of the scientific method, e.g., statement of the problem, research of the literature, tentative hypothesis, plan of experimentation, conclusion, and restating the hypothesis. A minimum for all types should be the problem, plan of investigation, and conclusion or summary.

In developing the plan of the project and in selecting the project, the teacher should bear in mind that he is acting as a guide and a resource person. He should not select the project or actually construct the study plan. However, he may explain the various types of investigation to the students. He may suggest occasionally but the final decision and plan should be that of the student.

The project may take a considerable length of time or it may be rather short. A student may do one or more projects in a year. Class time may be given to the projects, but the projects make wonderful science club activities. The writer prefers to use them as the latter.

The value of a project is to allow creativeness, discovery, incite interest, expand learning, and enhance the field of science to the student. Its value cannot be overestimated.

Presentation and Use of the Method

In presenting the Principle-Unit-Project Method it is wise to hand the student an instruction sheet. This will explain to him how the method functions. The sheet should contain an Introduction, the Parts of the Student Unit and how they function, Plan of Study, Requirements of the Course, Explanation of the Laboratory Work, Projects and Evaluation. All of these have been previously explained except the Plan of Study and Requirements of the Course. These are combined occasionally and the following is cited to give the reader an understanding of what is wanted.

The Plan of Study consists of explaining to the students the use of various parts of the Student Unit.

The use of notebooks should be encouraged. The student should be required to have a complete notebook. Grades on notebooks should not be encouraged, but they should be marked complete (satisfactory) or incomplete (unsatisfactory). Observation has shown that when notebooks are complete the student's test grade will rise.

The laboratory sheet should be completed during laboratory time or shortly thereafter and should be filed in the notebook with the unit.

When drawings are to be done, they should be done with care,

labeled, and placed with the unit. Field trips should be written up and a record of collections made in the notebook. Film summaries should be encouraged. However, if there was a lively class discussion in which all participated following the film, this may be dropped. Students should put a copy of their student reports in their notebooks for this may be useful at a later date by serving as a reference.

Summary

The Principle-Unit-Project Method accomplished much that is desired in science teaching, e.g., the use of philosophical and psychological theories, allows for creativity, has directed activities, contains material for three ability levels (ability grouping), creates and helps to stimulate interest, gives freedom in the use of methods, brings about close teacher-pupil relationship, gives direction to science club activities, has objective and subjective grading patterns, includes use of new and current science material, uses and explains fundamental principles, increases the vocabulary, provides for knowledge of facts as well as the comprehension and application of them, gives training in thinking, gives deeper and broader coverage of the subject matter, and helps to bring interest and abilities closer together.

The method places a responsibility on the teacher in that he must know his subject matter and put into practice his professional training. He must be a leader and a subject matter counselor.

Teaching is really made easier by the use of this method although it does take time to prepare. Many teachers in college and high school have a tendency to slip into a rut in their teaching. This may be so with a teacher who uses this method, but with the changing of textbooks or the publication of new editions, the teacher will become more aware that his material is old or obsolete. Also, the listing of publication dates of certain magazines or periodicals in the reference list will eventually make the teacher and student recognize the age of his data.

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Implications of Technical Manpower Shortages for Science Teachers

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The fact that the American press often writes about manpower shortages in science relative to the United States and Russia may leave an impression that these are the only two countries deeply concerned with these problems. But, in reality many other countries are faced with similar technical and scientific manpower problems and, like the United States, are endeavoring to rectify the present lack of personnel in these areas.

The British government, for example, has long been concerned about the shortage in the supply of their technical specialists. Since 1956, Britain has been seeking to develop further its manpower resources by giving considerable financial aid to technical institutions. Eight colleges, designated as institutions of advanced technology, have been enpowered to give special diplomas to those trained in the technical fields. This advanced technology degree has been deemed by the Ministry of Education to be similar in status to degrees received through university training.[1]

France is also experiencing manpower problems in the technical fields, especially in engineering. The French government estimates that in order to meet the demands of their expanding technical developments, France will need twice as many engineering graduates in 1961 as they graduated in 1957.[2] As a consequence, the government has established new institutes for the training of additional engineers and scientists. Special preparatory classes in mathematics and science in the secondary schools have been organized for students and workers whose backgrounds in these subjects are inadequate. This makes it possible for individuals to remedy their deficiencies in mathematics and science in preparation for the national examinations, the successful passing of which enables a person to enter higher education.

Germany is experiencing manpower shortages similar to those found in France and other parts of Europe. Germany needs more men trained in electronics, drafting, engineering and in practically all fields of physical science. The West German Government in its *Annual Report on Education* to the United Nations stated that many of the individual German states have increased facilities and added courses in science for programs in night schools.[3] This was done so

[1] Ministry of Education, *Education in 1958*, (London: Her Majesty's Stationery Office, Cmnd 777, June 1959) p. 39.

[2] U.N.E.S.C.O.; *International Yearbook of Education*, Vol. XIX, No. 190, United Nations, New York, 1957, p. 166.

[3] *Ibid.*

that talented individuals can obtain further training in order to prepare themselves for positions in industry and engineering. The opening of additional courses in night schools has made it possible for far more individuals to enter the technical and engineering colleges than had been previously the case.

Denmark perhaps is outstanding in its efforts, starting early in the elementary grades, to make the sciences attractive and interesting to pupils. The Rodkilde School in Copenhagen, a comprehensive school which the author visited, has a continuous science program through the elementary grades. Although Rodkilde is not a high school, it is better equipped with scientific apparatus than are many secondary schools in America.

Manpower shortages exist throughout the Western European countries. The efforts of these nations to remedy the situation by increasing the number of scholarships in the technical and scientific fields, through revision and improvement of the curriculum, modernization of equipment and facilities, and extension of instruction at night schools and technical schools parallel steps taken in the United States. The rapidly expanding technology in each of the European countries, plus the fact that some of those countries must send technical experts to their colonies and to other less well-developed areas of the world, tend to aggravate the manpower shortages.

In all probability the demand for scientific and technical manpower will continue to increase geometrically. It must be remembered, however, that technical advancement is contingent on an ample and progressively improved supply of able manpower. This supply can only come from the schools and more particularly from those students trained in the disciplines that best prepare individuals for technical work. As a consequence, the role and responsibility of science and mathematics teachers become more significant in the economic foundation of a technical society. It is paramount that these instructors make additional efforts to attract individuals, who have the potential, into the scientific and technical areas of study so that the manpower demands of the society are met. Teachers of science and mathematics can better assist in this task if they attempt to do the following:

1. Reveal to their students the *world-wide* possibilities for employment in the technical fields.

2. Describe and discuss the activities of the various technical and scientific professions. Such discussions should not be limited only to the top professional levels but also should include comments about opportunities in such technical occupations as X-Ray Technician, Laboratory Technician, and Electronic Technician.

3. Develop the concept that science is always on an expanding frontier by involving students in meaningful research projects.

Science should not be taught as though it were a static subject in which all the problems have been solved. Rather science should be taught to stimulate students to think of the contributions they might make to the advancement of scientific information.

4. Widen the vision of their students by making their science courses more interesting and dynamic.

Science and mathematics teachers who attempt to implement these suggestions in their classrooms can better stimulate students to take an active interest in contemplating some scientific field for their life work. Furthermore, instructors who see the world-wide implications of their work are more apt to make an effort to discover latent scientific potential in their students. These teachers are better able to convince students of their latent ability and possible future success in science. Instruction of this caliber serves not only the individual, but the community and country as well. In the achievement of these objectives, teachers may aid decisively in improving the manpower supply and prepare students better for the technical world they will move in tomorrow.

Simple Three-Pole Magnet

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A simple and inexpensive three-pole magnet for demonstration and experimental purposes may be made by using a steel safety pin. The size is immaterial, but one an inch and a half long will be appropriate for laboratory purposes.

Magnetize the pin with the point sheathed. When the pin is opened, it will be found to be an instance of two like poles at the point and clasp ends and an unlike pole at the other end. Force the opened pin into a straight length and use iron filings or a small compass to study the resultant magnetic field. A little experimenting will show that the two like poles will have equal intensity, but each will be only half as strong as the central pole.

Students will find this a facinating device for studying the principles of multi-pole magnets. The principle can be expanded to any number of odd or even poles (other than one) by suitably folding, say, a piece of steel wire into n tightly folded lengths and magnetizing the composite. When the wire is straightened, it will have $n+1$ magnetic poles. Like poles will occur at alternate points along the wire, and there will be an odd number of one type of pole if n is even, otherwise, the number of S-poles will equal the number of N-poles.

Administrative Practices in Secondary Mathematics Curriculum Experiments

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Introduction

The mathematics now taught in the secondary schools is at least three hundred years old and some of it is more than three thousand years old. Ninth grade algebra includes problems similar to some found on the Rhind Papyrus. Geometry is essentially that which Euclid knew. Our present algorithms of arithmetic are more than five hundred years old. Even in the eleventh and twelfth years where one might expect more modern topics algebra is four hundred years old, analytic geometry three hundred fifty, and calculus about three hundred.

Mathematics developed in the past three hundred years and particularly that of the past one hundred fifty years has largely been ignored in the secondary school and in the colleges, too, as a matter of fact. This mathematics is quite different from that which preceded it. More mathematics has been developed in the twentieth century than in all previous history. We are in the midst of a revolution in mathematics.

Lagging behind, but sometimes quite close, are the applications of modern mathematics. As has always been the case the mathematics must be developed before the scientists and technologists can apply it. One need only look at the tremendous technological age of today to realize what modern mathematics has generated. But new mathematics is pouring out at a terrific pace and we can only speculate as to our future. It seems reasonable to say that the future can not be forecast. We must prepare our youngsters to live in a world different from the present one. Can mathematics of three hundred years ago do this task?

It may be argued that modern mathematicians studied present secondary school courses and were able to produce new mathematics. Also, one hears that without a thorough background in traditional mathematics the new material is incomprehensible. Finally, it is said that since mathematics is sequential none of it can be omitted and this means that modern mathematics can be studied only after all the old has been mastered.

Such criticisms are false. Perhaps our modern mathematicians have done well despite their traditional background. Next, no one has ever studied all previous mathematics before undertaking new topics: Gauss is said to be the last person to fully grasp all fields of mathe-

matics and he died in 1855. Furthermore, only one Gauss has graced the pages of mathematics history. Some experiments seem to show that modern topics can be understood by secondary students who have not studied the traditional sequence. Of course, not even the present pattern contains all past mathematics, instead it is the result of much culling and choosing. The question is whether or not the selection of topics should be made from a more up-to-date list.

The present secondary mathematics curriculum is sixty to one hundred years old. It received strong support from faculty discipline at a time when changes should have been made. Mathematicians largely ignored the secondary school; colleges demanded the traditional courses for entrance; colleges built their courses on this traditional base and included modern topics only at the graduate level; teacher preparation programs turned to improvement of methods of teaching traditional topics and to the psychology of learning while ignoring new content; authors wrote texts they were sure would sell; and administrators, beset by new demands of a new school population, let a sleeping dog lie and welcomed general mathematics to take care of those who couldn't or wouldn't learn the traditional courses.

Only in the past ten years has anything worthwhile been done on the problem. Several groups are tackling the problem of modernizing the secondary mathematics curriculum. These groups have combined the efforts of mathematicians, teachers, and psychologists in order to develop a program suitable to all. Furthermore, these groups are attempting to provide a complete solution. They are preparing materials suitable for students, they are providing in-service training for teachers, they are assisting in the evaluation of experiments, and they are providing the publicity and promotion necessary for the widespread acceptance of a new program.

Many individuals have believed that they might contribute to the emerging curriculum in their own schools with their own materials. Thousands of teachers have studied modern mathematics in summer programs and many of them want to try teaching new content to their students. Unfortunately, less attention has been given to the techniques of experimentation than to content. Also, "home-made" plans often lack the prestige of nationally known efforts and administrators may be more reluctant to support them. And, experimentation creates administrative problems which no administrator wants to add to his collection of problems unless he is convinced of the value of the proposal.

In order to assist teachers and administrators with some of the problems attending curriculum experiments, a survey of practices was made. This survey included an examination of the literature and questionnaire sampling of various teachers, supervisors, and admin-

istrators who were known to be experimenting. A report of the study follows.

Questionnaires were mailed to 39 teachers or administrators who were thought to be doing some experimenting with curriculum. 21 replies described experiments ranging in size from one class to 35 schools, 7 other replies indicated no current work of this kind. Some 100 periodical articles on curriculum experiments or curriculum were also examined. Questions, findings, and comments are as follows:

1. *Are teacher loads adjusted to allow time for planning experiments? If so, what adjustments are made?*

Findings. The most common answer was "no adjustment." A few schools reported that each teacher was allowed one free period per day. Curriculum directors and those involved in curriculum studies other than mathematics want teachers, administrators, children, parents, psychologists, and lay people to participate in the planning. Mathematics teachers seem to want little outside help.

Comments. If all teachers in a school are allowed one free period per day this probably is a preparation period rather than a planning period. Teachers should be given time during the school year or in the summer to plan experiments. Administrators should encourage all concerned to participate in curriculum planning. Poor preparation and/or poor planning would probably result from a lack of planning time.

2. *How are teachers chosen for experimental sections?*

Findings. We choose: young, enthusiastic teachers; experienced, proven teachers; teachers interested in experimenting; and those who have training in modern mathematics through National Science Foundation Institutes or similar programs.

Comment. Experimental sections taught by average, disinterested, or even antagonistic teachers may also yield valuable information.

3. *What adjustments, if any, are made in teaching assignments and in activities for teachers assigned to experimental sections?*

Findings. The Minnesota group reported that teachers receive one-sixth extra pay for teaching experimental or control sections. Shawano, Wisconsin reported that some adjustment is made in activities assignments. Madison, Wisconsin also allows some extra time for these teachers. Others say none.

Curriculum experts ask that experimenting teachers be given extra time. No matter how carefully plans have been made problems will arise which call for adjustments in materials and methods.

4. *How are students chosen for experimental sections?*

Findings. While some schools do not sort students, most of them do select students in some way. Selections are made on the basis of teacher recommendation, mathematics grades, scores on standardized mathematics tests, pupil and parent interest, reading scores, IQ, EQ, and aptitude tests.

Comments. Better students are generally selected for experiments. This would imply that these new courses are designed for gifted or superior students or that experimenters want to be sure the results are good.

Grouping by these methods mentioned is common in mathematics and probably is responsible for such division for experimentation. No one said that any attempt was made to equate groups, in fact, it seems likely that control groups are not used in many of the experiments.

Courses for the gifted are appropriate, but experimental work needs to be done for the average and poor students also.

5. *Are study loads adjusted for students in experimental sections?*

Findings. Madison, Wisconsin and Proviso Township, Maywood, Ill. reported that students in advanced courses were limited in study load or in activities, but all others answered no to this question.

Comments. Experimental courses aimed at replacing traditional courses probably should not call for more of the students' study load than present ones. Accelerated courses may require more study time.

6. *Is pupil progress reported differently for students in experimental sections?*

Findings. No.

Comments. In spite of the fact that new courses are being taught, teachers and administrators feel that they can identify A, B, C, D, and F work. I wonder what would happen if a student received a grade of F in a course which turned out to be no good?

7. *How is credit for experimental courses reported on college entrance applications?*

Findings. If courses are sufficiently like traditional courses they are called by traditional titles. If they are accelerated or different in other ways then a brief description of the course is included with the transcript.

Comments. This question was included because teachers frequently ask it and then follow it with a comment such as———— College won't admit our students unless they have credit in algebra, geometry, trigonometry, solid geometry, etc. Experimenters do not con-

sider this to be a serious problem, although teachers contemplating experimental courses almost always worry about it.

8. *How are experiments appraised?*

Findings. The Minnesota study and the University of Maryland project employ psychologists in evaluating their studies. Others use teacher opinion or student opinion or make no appraisal. Those who write on curriculum experiments urge careful, objective evaluation.

Comments. Evaluation is probably the weakest part of most small studies. Teachers probably do not have enough time or training to appraise most experiments. Guidance personnel (preferably psychologists) should head a group of concerned individuals in evaluating an experiment. At the very least teachers should set down specific goals before beginning to teach such sections.

9. *What other administrative problems have you encountered in curriculum experiments?*

Findings. Six schools mentioned the difficulty of scheduling the students they wanted into the courses they wanted them in. Four said that students not properly qualified for certain experimental courses insisted on being enrolled in them or that their parents did the insisting.

Other problems were: difficulty in placing students who move, change in teacher personnel, insistence by administrators on the use of standardized tests regardless of content, administrators want modern mathematics—teachers do not and vice-versa, some administrators and teachers do not want to experiment, and teachers are left on their own with little help from administrators.

A Final Comment

Mathematics curriculum will not be improved through haphazard, unscientific experiments. Well planned, carefully conducted experiments may be of considerable value to the profession. The best efforts of teachers and administrators are needed to improve the quantity and quality of mathematics curriculum experiments.

LIVING CELLS STUDIED

Parts of a living cell as small as a millionth of a square inch can be viewed and studied with an apparatus developed by Dr. Jerome J. Wolken, head of the biophysical research laboratory of the Eye and Ear Hospital in Pittsburgh. The $3,000 portable microspectrophotometer uses a photoconductive cell of cadmium selenide. Using this device Dr. Wolken can watch a living cell's chloroplasts, the units in which photosynthesis occurs. Understanding of the interaction of light with living systems is one objective of Dr. Wolken.

CHALLENGING THE IMPOSSIBLE

George G. Mallinson, Editor

Since the writer has been functioning in the capacity of Editor of SCHOOL SCIENCE AND MATHEMATICS, many controversial articles in both the fields of science and mathematics have been received. Some of the authors of these articles have sought to attack problems long thought impossible of solution. A number of letters have been received excoriating the policy of the Editor in mentioning certain of these efforts even when the material was not published. In fact, one of the supposedly outstanding mathematicians in the United States commented about one effort in his letter as follows:

"No, I haven't seen any of their material and I won't waste my time on it. I know they are wrong."

Such a statement is a reversion to barbarism. The Editor is certain that any scientist worth his salt is eager to examine a new idea for a perpetual motion machine to see how the hapless inventor sought to "beat the game." He is reminded also to the indivisible atom, the earth as the center of the Universe and the recanting of Galileo, and the conflicting views of inheritance.

At the meeting of the Board of Directors on May 7, 1960, the Editor requested and received the permission of the Board to publish some of the articles that are bound to evoke controversy under the heading "Challenging The Impossible." Some of them may deal with extremely "comment-provoking" topics, such as squaring the circle. They will be published without comment and without support or endorsement. The authors will be informed that they are "placing their heads on the chopping block." The readers may comment as they choose, but are requested to *write the author, not the editorial office.* These items are submitted in the hopes that the readers will attempt to search for any flaws that may exist, and inform the author. At the same time it is hoped also that the opportunity may stimulate more persons to "Challenge the Impossible."

A note by a Departmental Editor will accompany each article.

CHALLENGING THE IMPOSSIBLE

Cecil B. Read

University of Wichita, Wichita, Kansas, Mathematics Editor,
School Science and Mathematics

It is not at all difficult to propose an impossible problem. For example: Find an even prime number greater than three; Construct a triangle such that the sum of two sides is less than the third side; Find a positive number such that its square is non-positive. Few, if any, students of mathematics would attempt such obviously impossible problems. On the other hand, there are some problems which we suspect are impossible, but which have not been proved impossible. Examples are the four color problem (to construct, with suitable restrictions, a map in the plane which will require more than four colors to distinguish the various regions); Fermat's Last Theorem (find distinct integers, a, b, c, such that $a^n+b^n=c^n$ for n greater than two). These, if solved, would constitute a mathematical accomplishment of the highest order. There remains a class of problems which for many centuries were not known to be either impossible or possible, but which within relatively recent time have been proved to be impossible. Yet for some reason, many seem to be challenged by such problems, and insist in submitting "solutions."

Probably more effort has been expended on three of such problems than on all other "impossible problems." These three are often referred to as Duplicating the Cube; Squaring the Circle; and Trisecting the Angle. Stated more precisely, these problems, dating from the classical geometry of the Greeks, ask for the geometrical construction, using only a compass and an unmarked straight edge, which will

1. Give the edge of a cube whose volume is exactly twice the volume of a cube whose edge is known
2. Give a square whose area is exactly the same as the area of a given circle (or a circle whose radius is given)
3. Produce an angle which is exactly one-third the size of a given angle.

It must be noted that approximate constructions are not a solution, that the solution must be general (for example, trisection of an angle of 90° is not a general solution), and that no other tools or devices may be used (it is relatively simple to trisect an angle if two marks may be placed on the straightedge).

In spite of the fact that the impossibility of each of these three constructions has been rigorously proved, and that proofs are readily available in many references, it is the rare mathematics teacher who has not been presented with a "solution" of one of these problems. For some reason, the problem of trisecting the angle seems to attract many people. In many cases the proofs are long, involved, and obscure. Yet the individual seems to feel it a personal insult if his solution is not acclaimed with open arms. More than this, if errors are pointed out, the author either fails to admit there is an error, or else submits an even more complicated proof, which, it is claimed, is no longer in error.

Yet there may be merit in some of these attempts at solving the impossible. The analysis of proofs such as are sometimes submitted forms a very fine review of one's understanding of what is a proof; moreover, a student attempting to follow a rather vague and obscure construction and proof will be made much more cognizant of the reasons for clear and concise statements in his own presentations.

School Science and Mathematics proposes to present, from time to time, material of the type mentioned, wherein it is claimed that some "impossible" problem has been solved. It should be made clear that in such presentation, neither the periodical nor its editors are endorsing the validity of such "proofs." Rather, the material is presented with the hope that some readers will be challenged to find the flaw or flaws. Moreover, although there can obviously be no promise to publish every such article which is submitted, the presentation of an occasional one may free mathematicians from the frequently made claim that they refuse to even consider that the possibility exists that the proofs of "impossibility" are invalid.

CHALLENGING THE IMPOSSIBLE

The KIDJEL SOLUTION to the TRISECTING of the ANGLE using COMPASS and UNMARKED RULER

Maurice Kidjel in collaboration with Kenneth W. K. Young

3055 Kapiolani Blvd., Honolulu 14, Hawaii

It is rather puzzling why no mention is made in general mathematics literature the fact that there are *4* angles that can be easily trisected exactly with their respective arc radius using a compass and unmarked ruler only. They are 180°, 90°, 45°, and 135°. The question therefore arises as to why this fact has been omitted in all our school texts in geometry. We submit Diagram #1* which we are sure any first year geometry student can easily demonstrate. In view of this first diagram, we wonder why no further investigation was made to discover the true nature of this so-called "impossible" problem. From all evidence to date, no really serious approach to the solution has been made. It is true, however, that there are abundant displays of algebraic equations to prove that this problem is "impossible" to solve. This merely illustrates the presence of a puzzling vacuum in serious basic reasoning.

It behooved the author to go further by discarding the algebraic theories and thoroughly analyze the true nature of this vexing problem.

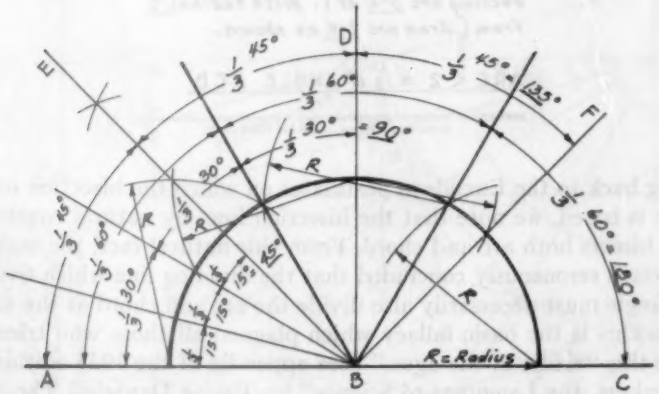


DIAGRAM #1 4 ANGLES TRISECTED with COMPASS & UNMARKED RULER.

∠ABC = 180° ∠ABD = 90°
∠ABE = 45° ∠ABF = 135°

1968 by M. KIDJEL
Drawn by K. YOUNG

* All diagrams reproduced with permission of authors.

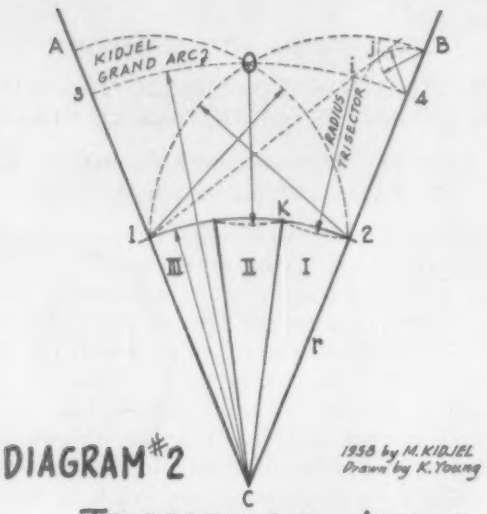


DIAGRAM #2

1958 by M. KIDJEL
Drawn by K. Young

TRISECTING the ANGLE

... WITH COMPASS & UNMARKED RULER ONLY!

With any radius r draw arc 1-2 as shown. Draw arcs 1-B & 2-A from 1 & 2. With radius C-O draw arc 3-4. With radius B-4 from 4 & B draw arcs intersecting at j. Draw line 1-j intersecting arc 3-4 at i. With radius i-2 from i draw arc 2-K as shown.

ARC K-2 = 1/3 of ANGLE ACB

IMPORTANT! Use 2 Hor 3H pencil, needle sharp! Register all points with precision!
Do not copy diagrams... DRAW YOUR OWN!

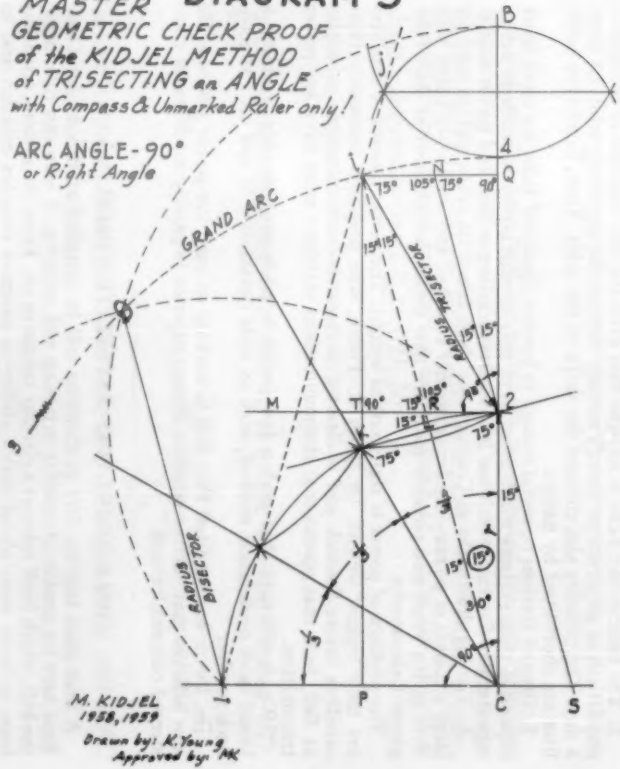
Going back to the Euclidean postulates on which the bisection of an angle is based, we note that the bisection line, by natural construction, bisects both arc and chord. From this natural fact, the mathematicians erroneously concluded that the dividing line which *trisects* any angle must necessarily also divide the arc and chord at the same time. This is the basic fallacy which plagued all those who tried to solve this "riddle of the ages." (See appendix of the 1933 edition of "Numbers, the Language of Science" by Tobias Dantzig.) The true solution lies in trisecting the *arc* of the angle. It is the *arc* that gives the true measurement of the angle. Let us, therefore, carefully analyze this along the following lines:

Since the bisection point is exactly midway between the two legs of the angle, it is natural that the trisecting point which is the "bisect-

MASTER DIAGRAM #3

MASTER GEOMETRIC CHECK PROOF of the KIDJEL METHOD of TRISECTING an ANGLE with Compass & Unmarked Ruler only!

ARC ANGLE - 90° or Right Angle



M. KIDJEL
1958, 1959

Drawn by: K. Young
Approved by: MK

MASTER CHECK PROOF

PLAN: To prove that arc 1-4 is ⅓ of grand arc and therefore determines the center from which the radius trisector cuts the arc of given ∠ 1-2 into 3 = parts. To also prove that line C is the bisector of ⅓ of the arc of a given ∠ and is also the radius of the grand arc of a given ∠.

STATEMENT	REASON
1. Trisect given ∠ with own Arc Radius	1. Nature of ∠ST by const'n.
2. Trisect " " by KIDJEL METHOD	2. Const'n. - Note: KIDJEL Method coincides point by point with #1. Rad. Trisector also = to given radius of given ∠.
3. ∴ ∠ KC2 = ⅓ of ∠ST or 30°	3. ∠ST = 90° ÷ 3 = 30°
4. Draw Chord K2	4. Const'n.
5. ∴ Δ KC2 = Isosceles Δ	5. Def. of isosceles Δ
6. ∴ ∠ 2KC and ∠ K2C = 75° ea.	6. Base ∠'s of Isosceles Δ are =
7. Bisect K2 at L to C	7. Const'n.
8. ∴ Δ KLC ≅ Δ 2LC	8. S.A.S. are =
9. Const. ⊥ M2 to side C4 of given ∠	9. Construct'n.
10. ∴ ∠ M2K = 15°	10. ∠ST M2C less ∠ K2C (75°) = 15°
11. Const. line N2S ⊥ to K2 forming ∥ is to LC	11. Const'n.
12. ∴ ∠ N24 = 15°	12. Rotation of Right ∠ K2N
13. ∴ ∠ N24 = C2S	13. Opp. ∠'s are =
14. ∴ ∠ LC2 = ∠ C2S = 15°	14. Opp. ∠'s formed by diag'l cutting ∥ lines are =
15. Extend line LC to i making iLC ∥ to N2S	15. Construction.
16. Const. line iP ⊥ to line 3C	16. Const'n
17. " " iQ ⊥ to line C4	17. "
18. Opp. ∠'s of ▱ RiN2 are =	18. Def. and nature of ▱
19. " " " Rect. TiQ2 " "	19. " " " " rectangle
20. ∴ iN = R2 and iR = N2	20. " " " " ▱
21. ∴ R2 = CS and RC = 2S	21. " " " " ▱
22. ∴ line iC bisects ∠ KC2 (30°) = 15° ⅓ of given ∠ST	22. ∠ KC2 (30°) − ∠ LC2 (15°) = 15°
23. ∴ arc 1-4 is ⅓ of grand arc 3-4 &. ∴ determines center of rad. trisector which cuts arc 1-2 into 3 = parts. Arc 3-4 being concentric to Arc 1-2	23. Q.E.D.
I. Draw line i2	1. Construct'n
II. ∴ Δ iL2 ≅ Δ 2LC	II Δ's with 3 = ∠'s & 1 side = to each other are ≅
III. ∴ line i2 (Rad. Trisector) = r	III " I

ing" point of $\frac{1}{3}$ of the angle must lie at $\frac{1}{6}$ of an arc. In short, there must be a point from which the radius, the length of which, must be the distance from another arc which then trisects the originally given arc. See the KIDJEL GRAND ARC 3–4 and the RADIUS TRISECTOR as shown in Diagram #2. Notice the very important point "*i*" which cuts the GRAND ARC 3–4 into exactly $\frac{1}{6}$. Therefore, it is conclusive that, in order to trisect an angle, one must locate $\frac{1}{6}$ of the GRAND ARC. See Diagram #3 of MASTER CHECK PROOF.

This is the first part of the KIDJEL SOLUTION to the trisection problem. We shall, if agreed to by the editor of the SCHOOL SCIENCE AND MATHEMATICS journal, submit further discussion and proofs to the solution of this so called "impossible" problem. If granted approval, we shall then demonstrate the intrinsic relationship between the KIDJEL RATIO (5.333/1) and the KIDJEL SOLUTION to the trisection problem.

COURIER-LIKE SYSTEM, NOT ECHO, SET FOR FUTURE COMMUNICATIONS

Of America's two communications satellites, the new Courier rather than Echo seems more practical to most scientific observers here. They say future operational communications systems will almost certainly be patterned after this newer satellite.

The reasons:

1. The balloon-like Echo is so light that even the tiny pressure of sunlight—one-fiftieth of an ounce on Echo's surface—lowers the satellite's orbit 3.5 miles a day. The pressure also changes the shape of the orbit. Thus, Echo-type satellites are short-lived by nature.
2. Ground stations powerful enough to bounce signals off Echo are much more expensive than systems which must have only enough power to reach an active repeater like Courier, which has its own broadcasting system and power source.
3. The big drawbacks of Courier—the short life of its tubes and its need for large amounts of power—are being rapidly attacked and overcome. Tubes with lives of ten years and possibly more are now under development at Bell Telephone Laboratories.

The problem of power is really one of weight. The power sources of satellites are their biggest weight. Dr. John R. Pierce, who proposed communications satellites before Sputnik and is director of research-communications principles at Bell, feels that operational communications satellites must have low-power transmitters.

"We should note that such a low power is made possible only by using a broad-band modulation method, such as wide deviation FM and an FM feedback receiver."

Dr. Pierce has reported that Bell is working on such low-power systems. He now believes that "active satellites appear superior to passive satellites for commercial communications."

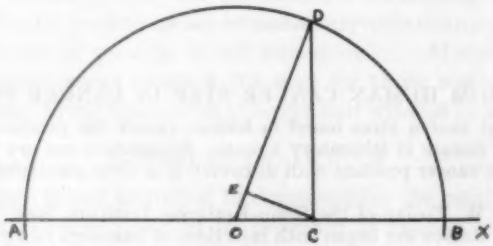
BALL SIMULATES SATELLITE TUMBLING

A fiber-glass ball ten feet in diameter will be installed at Brooks Air Force Base here for studies of satellite tumbling and spinning. A man can ride inside the ball, which itself rides on a circular stream of air. From the system, scientists hope to learn more about man's ability to perceive complex rotation and to tolerate the physical and mental stresses of rotation.

A Geometric Construction for the Arithmetic Mean, the Geometric Mean and the Harmonic Mean of Two Positive Numbers

Adrien L. Hess
Montana State College, Bozeman, Montana

When considering positive variates in statistics the question is often proposed to prove that the arithmetic mean $\geq$ the geometric mean $\geq$ the harmonic mean of the variates and that the geometric mean of the positive variates is the geometric mean between the arithmetic mean and the harmonic mean. A geometric construction for two positive numbers gives a picture of the relationship which is true for N positive numbers.



Consider the two positive numbers represented by the two lines a and b as laid off on AX so that $AC=a$ and $CB=b$. Using the familiar construction for finding the geometric mean (mean proportional) between two numbers a and b find CD. Draw OD. From C drop a perpendicular CE to OD. Now

$$OD=AO=\frac{a+b}{2}$$

is the arithmetic mean (A), $CD=\sqrt{ab}$ is the geometric mean (G), and

$$ED=\frac{2ab}{a+b}$$

is the harmonic mean (H). We note that triangles OCD and DEC are similar. Therefore,

$$\frac{ED}{CD}=\frac{CD}{OD}.$$

Substituting the values from above we obtain

$$\frac{H}{G}=\frac{G}{A} \quad \text{and} \quad G^2=AH,$$

thus proving that for two positive numbers the geometric mean is the geometric mean between the arithmetic mean and the harmonic mean. Using the values for the lines in terms of a and b

$$ED=\frac{2ab}{a+b}.$$

An examination of the lines representing the different means will convince one that for unequal numbers $A>G>H$. Only when $a=b$ will one use the equality.

VIRUS FROM HUMAN CANCER STEP IN CANCER PROBLEM

For the first time a virus found in human cancer has produced a new and characteristic disease in laboratory animals. Researchers are one step closer to solution of the cancer problem with discovery of a virus associated with human cancers.

Dr. Helene W. Toolan of the Sloan-Kettering Institute, New York, has announced that studies she began with injections of hamsters two years ago have been continued and confirmed by associates.

When inoculated into newborn hamsters the virus produces an unusual deformity characterized by small size, flattened foreface or microcephalic domed head, protruding eyes and tongue, absent or abnormal teeth and fragile bone structure.

The virus has been found in all eight of the transplanted human cancers tested but not, so far, in the cancer tissue itself nor in the tissues of normal individuals.

Dr. Toolan in an interview emphasized the fact that although the virus has been found in association with human cancers it is not known yet whether or not it is a factor in the cause of cancer or has any connection with cancer development.

"By using hamsters," she said, "we have set up an indicator system—a way of testing."

TEST SYSTEM FOR ALERTING DRIVERS

Motorists may soon have an electrical safety device that warns them if they approach too close to a pavement edge or center line. Such a device has already been developed by General Motors Corporation and will be tested here. A wire in the center of each traffic lane radiates low frequency power. Coils on either side of a car's bumper pick up electrical signals from the road. Thus if the car veers, one of the two coils gets a big boost in its signal and feeds it to one of two warning lights. The signal can also be fed to a speaker to produce an audible warning.

Geography's Place in the Liberal Arts College

Minnie E. Lemaire
Mount Holyoke College, South Hadley, Massachusetts

Although each liberal arts college will establish its own definition of the liberal arts, most agree on certain fundamental principles. These principles may be worded in different ways but they resemble the following statement published by Mount Holyoke College. "They are, the arts by which the thinking mind can find facts, can state truths, and can make good choices. The liberal arts are the tools of thinking, which our prececessors forged to make us free—free from slavish dependence on half-truth and error, free from credulity and the superstitious awe of learning, free from ignorance and the fear of seeming ignorant, but, most of all, free from skepticism and doubt of the value of thinking. They are the means of awakening the mind, of adding its life and growth to our evolutionary inheritance. The liberal arts are the arts of growth to full humanity. . . . Mount Holyoke's liberal education seeks to show the way for those whose growth in later years may bring ripeness of thought and wisdom in action."

History of Curriculum

A knowledge of the historical background for the establishment of the liberal arts college and of its program of change through time helps considerably in any attempt to assess the present. Higher education, at the time Harvard and Yale were established, was inspired by a strong belief in religion and represented an inheritance from English colleges such as Emmanuel College of Cambridge University. The European classical tradition dominated the curriculum with its strong emphasis on literature and the classical languages. Slight alterations were made in the program to study the problems of the moment, such as the surge of politics at the expense of religion, at the time of the revolution, but inherently the base remained the same. True enough, new fields of interest, such as mathematics, the natural sciences, and modern foreign languages started to edge their way into the curriculum and, generally, began to make themselves felt.

By the nineteenth century many people were questioning the predominance of the classical tradition with the result that by the middle of the century the liberal arts colleges had broadened their list of courses and had, to a large extent, accepted the idea that all subjects were important and of equal value if taught in the tradition of the liberal arts. This period saw the introduction of the sciences, as yet relatively new, untried and minus a long heritage. The acme for the sciences in the United States came with the launching of the first Russian rocket and the positive results of this impact are much too

recent to assess in an intelligent manner. Along with the growth and acceptance of the sciences came the expansion in other fields such as history, modern languages, political science and other social sciences.

Aims of Higher Education Today

What, though, can be said for the present status of higher education? The liberal arts college has often been the leader in projecting new thoughts and ideas in the past but seemingly has failed, to a great extent, recently, because it has held to the past and has not had a clear vision and goal generated by recent evolutionary changes in a more or less explosive world of thought and deed. This does not infer that we must deny our inheritance—far from it. Rather we must learn to evaluate our heritage the better to move forward. In so doing much of the past will be revitalized as having much meaning for our present day society. If logical improvement is to be attained, there must be a constant selection of values and processes that need to be continued and strengthened in an evolutionary change. Good appraisal means observation, selection and testing of observations, interpretation, and finally the drawing of conclusions. We must learn to re-examine our own conclusions as well as those of others.

What then constitute some of the present aims of education which seem to be emerging wherein geography can play a most constructive role? The Commission of Higher Education, appointed by President Truman in 1947, stated that "the goals of higher education that should come first in our time must be to bring all the people of the nation: 1) Education for a fuller realization of democracy in every phase of living: 2) education for international understanding and cooperation: 3) education for the application of creative imagination and trained intelligence to the solution of social problems and to the administration of public affairs." In many respects this suggests a shift in emphasis from educating a person for his own improvement as an individual to educating a person as a member of a group, local, national or international.

Certainly one of the major failures in education today, preparation for group responsibility, becomes evident as more and more problems of local communities come to light, such as the increase in urban slums, the deterioration of the central business districts and the growth of suburbia, all with their great impact on the human community. In a similar fashion problems which we fail to meet on a national scale, such as the optimum use of water resources and the surplus of agricultural products, indicate a weak point somewhere in our intellectual abilities. As the United States becomes more and more involved in the international scene, it behooves us as educated citizens to study the citizenry of the world so that we can know and under-

stand them better, can interpret their thoughts and actions more intelligently and can formulate policies for future action which will benefit all.

Geography—in General

Geography represents a distinct discipline within the great body of knowledge, with a point of view, an outlook and a search for answers to questions in a way utilized over a long period of time. It involves a body of data systematized by a distinctive analytical method. It does not have fixed boundaries and crystallized content so that the field of study is fluid. Just as there has been a change in the emphasis and the curriculum of the liberal arts college, geography, too, has evolved and tried to meet the needs and the demands of the present. Although we separate geography out as a special discipline it should not be taught with the idea of separateness but rather as a part to be linked constantly with the whole.

Seeking a proper and widely accepted definition or meaning of geography brings to light many possibilities but two components dominate (1) areal differentiation and spatial analysis or interaction and (2) man's activities in relation to this area and space. Hartshorne has stated that "geography is concerned to provide accurate, orderly, and rational description and interpretation of the variable character of the earth surface."[1] He goes on further to modify this somewhat by stating that "geography is that discipline that seeks to describe and interpret the variable character from place to place of the earth as the world of man."[2]

Geography as a Part of the Liberal Arts

In accepting the idea that a liberal education encompasses what we term the liberal arts or possibly the intellectual arts, then it need be shown that geography qualifies as a part of the liberal arts and is a tool of thinking whereby the "thinking mind can find facts, can state truths, and can make good choices."

"Geography seeks (1) on the basis of empirical observation as independent as possible of the person of the observer, to describe phenomena with the maximum degree of accuracy and certainty; (2) on this basis, to classify the phenomena, as far as reality permits, in terms of generic concepts or universals; (3) through rational consideration of the facts thus secured and classified and by logical processes of analysis and synthesis or laws of generic relationships, to attain the maximum comprehension of the specific interrelationships of phenomena; and (4) to arrange these findings in orderly systems so that

[1] Richard Hartshorne, *Perspective on the Nature of Geography*, Chicago, 1939, p. 21.
[2] Hartshorne, *op. cit.*, p. 47.

what is known leads directly to the margin of the unknown."[3]

As a tool of thinking geography does not seek out facts just to make a compendium of facts but rather to use them to show relationships by using inductive reasoning, by providing for logical sequences, and by encouraging selection, all of which lead to the need for making choices thus developing judgment for drawing conclusions and stating truths. The skills needed to aid this type of thinking encompass a variety of techniques. In terms of investigation, the library, and all that it represents with its wealth of information, offers a tremendous opportunity too often used in a limited fashion. Interviews are receiving an ever increasing amount of attention and need more refinement. Field work, the very base for geographic knowledge, must become almost second nature to a geographer if the library, the interview and other means of acquiring knowledge are to have meaning. Measurement and calculation aid in making the process of geographic thinking more vital. The complexity of forces involved for geographic study requires quite active and complicated thinking.

If geography is to meet its obligation as a part of liberal arts, then it must offer itself as a field for fundamental research. Geography has as its unique scientific method of procedure the study of the areal differentiation and the spatial analysis of both the physical and the cultural, or human, characteristics of the earth's surface. These interrelationships do not necessarily involve just cause and effect, per se, but something larger with greater meaning and impact, because a chain of events will generally follow a change or an event. This will differ from place to place depending upon circumstances such as the needs and the technical abilities of the people involved and the present and future plans for development. For instance a dam constructed on a stream in New England may mean water power or flood control with improved facilities for industrial expansion with all its consequences whereas in New Mexico it may mean irrigation with improved conditions for commercial agriculture with all its consequences. Stephen B. Jones in writing of such relationships stated that in order "to give it a more operational flavor (he) prefers to speak of 'repercussions' "[4]

"Within a pattern of emphasizing process, fundamental research in geographical science can be important. The world is becoming more crowded daily by the sheer impact of the individual human being upon the physical sustenance provided by the earth, through increasing wants and improving resource conversion. It is a world still emerging from the simple space relations of agricultural and trading

[3] Hartshorne, *op. cit.*, pp. 169–170.

[4] Stephen B. Jones, "Geographical Thought in the United States," *Perspectives U.S.A.*, No. 12, summer 1955, p. 74.

societies to the extremely complex relations of advanced industrial societies. Such a world is one which strains the capacity of science to provide comprehensive detail for the understanding of those relations. Cultivation of the only science devoted to earth space relations would seem a useful part of a program in fundamental science."[5] A most significant and valuable result from such research will show that the studies generally known as scientific and humanistic are not disconnected but closely allied.

Group Membership

Geography, which is an essential part of life, certainly can contribute much to "the arts of growth to full humanity" for it has a vital interest in "the world of man." Thinking of this as group membership, what does geography have to offer in a more specific manner? Regional analysis, with its study of the spatial interplay of forces and of interrelationships, may involve areas of different size from small to large. From the local point of view, for instance, urban geography is receiving more and more attention and the techniques for interpretation have been improved greatly in the last few years. Certainly any citizen with such a background should be conscious of what exists in his home setting and should be able to take an intelligent part in community life after graduation and especially after marriage when he is concerned with the community as a home for his family.

People with a great appreciation for a local community and a good quality of imagination should be able to project their thinking to include regional aspects on a national scale. Here such regional geography courses as Latin America, the Mediterranean, or Africa, South of the Sahara, will enlighten the student for larger group action. Once the national patterns have been explored and better understood, then the mind is better prepared for a more intelligent comprehension of the play of international forces and actions.

The base of all this group membership derives from a fairly thorough understanding of peoples in relation to their homeland. Such an understanding will lead people away from the restricted and often scornful tolerance of other peoples and of their culture to the enhancement of the highest Christian principles of the understanding and the appreciation of mankind. By setting a high moral tone and giving a greater meaning and significance to life a new world of thought can be discovered and a sympathetic philosophy of deed and action will be encouraged. This, in no way, precludes comparison and criticism, but rather takes them out of the category of destruction and

[5] Edward A. Ackerman, "Geography as a Fundamental Research Discipline," Chicago, Illinois, 1958 pp. 36–37.

puts them in the setting of construction.

Although geography tends to emphasize the present, it must study our "evolutionary inheritance" as a clue to the present which will aid in the prediction of the future. Geography provides the fairly stable base on which people build and so gives a greater feeling of stability in this chaotic world. In spite of doctrine, various philosophies and political theories, there is a firmament from which to start. Then geography presents change as the rule, not as the unusual, so that the discipline is dynamic and kinematic.

Practical Value

Although a liberal education does not pretend or claim to be of practical value, and rightfully so, this does not mean that practical results will not accrue. It is not necessary to deviate from the philosophy of the liberal arts to accomplish something practical, rather the philosophy of geography as a vital part of the liberal arts, if correct and sound, will accomplish this. Practical work, an honorable and necessary activity, often provides an incentive for advanced study and for fundamental research. Preparation for a professional life in the field of geography may lead to teaching, to government service, to marketing research, to city and regional planning, and to an ever increasing number of new opportunities.

Conclusion

The liberal arts college, especially in the eastern part of the United States, has not included geography as an essential part of its curriculum and encouraged it on the same basis as other disciplines such as history, economics, chemistry or zoology. This situation points to one of the weakest spots for geography in the whole picture of higher education in the United States. Although the European tradition and heritage still permeate the general curriculum structure of the liberal arts college, the strong position of geography in European higher education has not carried over and been accepted.

With the movement to change teachers colleges into liberal arts colleges, strong preparations must be made not only to keep geography in the curriculum but also to strengthen it. In a similar way as junior colleges are established and follow, to a large extent, the liberal arts program, the administrator and curriculum committees should have a forceful case for geography presented to them. One of the most heartening examples of the acceptance comes from the strong position geography has taken in the newly established junior-community college system of Maryland.[6]

[6] Robert T. Novak, "The Status of Geography in the Nine Public Junior-Community Colleges in Maryland," *Journal of Geography*, LVIII, 8 (1959), pp. 407–410.

As encouragement is given to regional or area studies in the liberal arts college by the foundations, such as the Ford Foundation, geographers must step forward and make themselves heard in a more vigorous manner for geography has already developed the techniques for such studies which fact is seemingly not thoroughly appreciated by those who are proposing and sponsoring such projects. Even though the geographer has not been included or consulted in the planning programs, it behooves him to take the initiative and state his position.

If the liberal arts college expects to lead the way in the near future, it must recognize the world scope of interests and break forth with new ideas and methods to encourage the study of its various parts. Herein, geography has a vital part to play because it has the ability not only to study the individual parts but also to synthesize these parts for the whole. Although attuned to the present, it encompasses a rich heritage. The sooner, therefore, students are permitted and provided the opportunity to study geography at the college level, the better we, as a nation, will be able to handle our place in world affairs.

In the final analysis the liberal arts graduate with geographic background and training, when properly inspired and creatively active, will provide the best proof of the part geography means in the liberal arts college.

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"POSITIVE" APPROACH PREVENTS CORROSION IN CHEMICAL INDUSTRIES

Corrosion is prevented in the chemical process industry by placing a positive charge on the metal to be protected in a new approach to the problem. Such a positive charge produces "passivity" in the metal. This method is called anodic protection. Anodic protection has been successfully applied to the sulfuric acid industry.

Use of Latin Square in Assignment of Pupils

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This paper is presented with the thought that an application of the Latin square in a familiar situation may be of interest to teachers. The usual application of this square in agricultural experimentation is likely to seem remote and therefore uninteresting to many people.

The importance of the Latin square is that it permits a kind of randomization which leaves certain properties invariant. As explained below, random permutation of rows and columns in the Latin square does not alter its property of being such a square. The ordinary concept of randomization, like drawing numbers from a hat, is thereby extended in an interesting way. An intermediate type of randomization is provided by random choice of permutations, which one might use in randomizing responses in a multiple choice test.

Problem

Sixty-six students are to participate in a two-day discussion of social issues. There are to be six group discussion leaders each of whom is a specialist in some area like welfare or housing. Each group leader is to conduct six discussion periods in his area, meeting eleven students in each period. There will be in all thirty-six discussion groups which will be referred to as classes.

Each of the students is expected to participate in one discussion led by each of the group leaders. It is further desirable that the classes differ from each other as much as possible in student composition, so that as a student moves from leader to leader he participates in discussion with different students, rather than staying with a fixed group throughout.

The problem then is to assign pupils to classes so as to make the preceding possible.

The Latin Square

The basic instrument to be used in making the required assignments *is* the Latin square, an example of which follows:

The square is characterized by the fact that it consists of six rows and six columns made up of repetitions of the six letters A through F. Each letter appears once and only once in each row and column.

The Latin square can be applied to the assignment problem by identifying a student with a letter, a column with a group leader and a row with a period. Six students can then be assigned so that each one of them meets all of the six group leaders. Thus, we note from the

TABLE 1

A TYPICAL LATIN SQUARE

	I	II	III	IV	V	VI
1	A	B	C	D	E	F
2	B	C	F	A	D	E
3	C	F	B	E	A	D
4	D	E	A	B	F	C
5	E	A	D	F	C	B
6	F	D	E	C	B	A

above Latin square that student A meets group leader I in period 1, group leader II in period 5, group leader III in period 4, etc. The reader may verify that all six students meet all six leaders at different periods.

USING A SET OF LATIN SQUARES

To this point, the Latin square has been used to assign only six students. In order that all students should be assigned, one may consider dividing the entire group of sixty-six into eleven subgroups of six, and applying the Latin square in Table 1 to each subgroup. This procedure would assure that each pupil shall meet every leader. The classes, however, would not be varied in composition. They would proceed as fixed cohorts of eleven from leader to leader.

In order that the classes should be varied in composition, it is necessary to use a different Latin square for each group of six students, eleven squares in all. Fortunately, many Latin squares can be constructed from any given square by interchange of rows, columns or both. Table 2 shows two Latin squares, the left one of which was obtained by interchange of rows in Table 2 and the one on the right by interchange of columns in the square on the left.

TABLE 2

LATIN SQUARES FROM TABLE 1

Interchange rows of Table 1						Interchange colums of left square					
B	C	F	A	D	E	E	C	A	F	B	D
E	A	D	F	C	B	B	A	F	D	E	C
A	B	C	D	E	F	F	B	D	C	A	E
F	D	E	C	B	A	A	D	C	E	F	B
C	F	B	E	A	D	D	F	E	B	C	A
D	E	A	B	F	C	C	E	B	A	D	F

More Latin squares can be obtained by further interchange of rows and columns in any of the squares formed so far. A selection of additional squares which cannot be obtained by mere interchange of rows

in columns of Table 1 can be found in Table XV of Fisher and Yates.[1]

To see concretely how the Latin squares are used, suppose that the sixty-six students are numbered as 1 through 66. Let students 1 through 18 be assigned to letters in the three squares formed above as shown in Table 3.

TABLE 3

ASSIGNMENT OF STUDENTS 1 THROUGH 18 TO LETTERS IN LATIN SQUARES

Square	Assignment to Letters					
	A	B	C	D	E	F
Table 1	1	2	3	4	5	6
Table 2 left square	7	8	9	10	11	12
Table 2 right square	13	14	15	16	17	18

If all three squares are then treated as the one in Table 1 so that columns are group leaders and rows are periods, the assignments to periods 1 and 2 appear as in Table 4. The complete tabulation to include all students, periods and group leaders can proceed in the same way. The required eleven Latin squares can be made up from the one in Table 1 by rearrangement of rows and columns using random permutations of six, or by drawing on the squares in the book of Fisher and Yates referred to above.

TABLE 4

ASSIGNMENT OF STUDENTS 1 THROUGH 18 IN PERIODS 1 AND 2, BY GROUP LEADER

Period	Assignment by Leader					
	I	II	III	IV	V	VI
1	1	2	3	4	5	6
	8	9	12	7	10	11
	17	15	13	18	14	16
2	2	3	6	1	4	5
	11	7	10	12	9	8
	14	13	18	16	17	15

To interpret Table 4, consider a set of three numbers in a column as a partial class. Then students 1, 8, 17 are part of a class which meets leader I in period 1; students 1, 12, 16 constitute a partial class meeting leader IV in period 2, etc. The complete tabulation has 36 classes of 11 pupils each.

Other Designs

The situation when the number of leaders and number of periods are exactly the same lends itself to easy treatment by use of the Latin square. When these numbers are not the same, other designs may be similarly applicable. Such designs are treated in books on experimentation like the one by Cochran and Cox.[2]

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1. Fisher, R. A. and Yates, F. *Statistical Tables*, third edition, Hafner, New York, 1949.
2. Cochran, G. W. and Cox, G. M., *Experimental Designs*, second edition, John Wiley, New York, 1957.

SHUFFLED CELLS CAN RECONSTRUCT SAME ORGANS

For the first time scientists have demonstrated that completely reshuffled cells, taken from the liver or kidney of chick embryos, can reconstruct the same organ without outside direction.

The new technique opens the possibility of further explorations by biologists who may use it as a clue to understanding disturbances of self-organization that lead to malformations and tumors.

Two Rockefeller Institute scientists, Drs. Paul A. Weiss and A. Cecil Taylor, report in the Proceedings of the National Academy of Sciences, that they incubated the cells of each organ for a brief period in pancreatin, an enzymatic extract of the pancreas.

The chick embryos from which the organs were removed were from eight to 14 days of age, and were developed sufficiently to have bodily movement. (It takes approximately 21 days to hatch a chick egg.)

The scientists scrambeld the cells from the removed organs (after stripping them of the physiological "glue" that binds them together) into a random mass and placed this on the surrounding membrane of eight-day-old chick embryos left to grow in their shells. In this way the graft received nutrition and blood supply.

After nine days of development, the professors removed the transplanted mass and studied sections under the microscope. They discovered typical miniature organs from which the cells had been taken.

Whatever the blood supply and chick membrane may have contributed to the advanced development of the formations they "certainly could have added nothing to make the liver cells reconstitute a typical liver; the kidney cells, a typical kidney; and the skin cells, feathers," the investigators observe. The blood supply and place of development were identical for all of them.

CANCER PROVED CONTAGIOUS FOR THE FIRST TIME

Cancer has been proved contagious for the first time.

Rous sarcoma, a virus-caused cancer found in chickens, can be transmitted from bird to bird by direct contact it has been found.

Until now Rous sarcoma, which has been used in research for 50 years, was thought to be non-contagious. Studies to date suggest that similar virus-caused cancers may also prove contagious.

The new find not only lends weight to the belief of many scientists that viruses cause some forms of animal and human cancers, but also may aid in fighting these diseases.

THE MASTER'S DEGREE—SECONDARY OR COLLEGE QUALIFICATION?

Marc A. Laframboise

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Debatable as the notion may be, the doctorate should be considered the desirable qualification for college competence in teaching.

However, in the next decade colleges and universities will need at least 27,000 new teachers a year. The present Ph.D. output is 9,000 a year. Of these, fewer than half become college teachers.

Effective teaching requires an understanding of the methods of inquiry through which knowledge in the particular field is discovered, tested, revised and extended. Thus, aspirants for high school teaching posts must have a substantial amount of graduate work in their particular field of competence. Those aspirants for college teaching must of necessity have much more of the graduate work, since effective teaching also requires the possession of a substantial body of knowledge.

By increasing the number of teachers who are scholars in their respective branches of knowledge, a desire for learning and the pursuit of excellence may be aroused in a larger number of our secondary and college students since because of their competence these teachers will be trusted and admired.

In addition, of course, to the academic program the professional program must provide a basis for the continuing pursuit of knowledge in the chosen area of study, and the development of a spirit of speculative inquiry will further the acquisition of skills in motivation and guidance.

The professional teacher will develop productive methods of thinking in the philosophical and historical areas. Proficiency will develop with contacts and the observation of skilled practitioners. A good program represents an extension of and not a replacement for liberal education.

Many schools at present are strengthening their requirements for teaching majors. In mathematics, the ideal of course remains the 24-semester-hours-beyond-calculus major recommended by the Commission On Mathematics of the College Entrance Board (Sept. 1957).

However, many schools still accept as teaching major in mathematics two or so courses beyond the calculus. Some of these same institutions will then grant the master's degree in mathematics with the equivalent of one year of study beyond this inadequate major. These departments recognize the meagerness of the requirements but hope that the stronger students will elect stronger courses.

This presents something of a paradox since the master's degree by its name implies mastery of a subject. Could not the master's degree be granted only to those candidates displaying mastery? Such mastery would normally result from some two years of successful concentrated graduate study beyond the recommended Commission's major. Broadly, this could include practically all of the present academic preparation for the Ph.D. but minus the thesis.

The University of Chicago has recently inaugurated a two-year graduate program beyond the B.A. degree for future high school teachers. The Master of Arts in Teaching in a specified teaching field will be awarded to those attaining satisfactory competence. This is a big step forward and establishes definite distinctions in the master's degree for high school qualification.

Many educators are reluctant to alter conventional ideas relating to the master's degree since symbolically this degree represents the ultimate qualification for the elementary or secondary school teacher seeking perhaps a life certificate or the maximum salary.

This writer would make the following suggestion. Where teachers spend a single year doing graduate work in the subject of their choice, say mathematics, to further competence in teaching, these might be granted a Master of Education in Mathematics degree M.Ed (Math), or if in say English a Master of Education

in English degree M.Ed (English). Those teachers obtaining the usual master's degree in education might be granted the M.Ed (Educ.) degree.

These could be recognized primarily as professional degrees for high school and elementary school teachers. They would still be master's degrees and would represent a desirable and ultimate level of professional competence.

Those candidates actually mastering a subject which mastery would usually require some two full years or more of successful graduate study beyond the recommended Commission's major (in mathematics) could be granted the Master of Arts or Science degree, M.A. or M.S.

This master's degree could then, and rightly so, be accepted as adequate qualification for teaching college and/or university work.

The doctorate would, however, remain the desirable ultimate qualification.

CONVENIENT FRACTIONS

Attractive exercises in the addition and subtraction of fractions can be made in great variety by means of an identity,

$$P/AB+Q/BC=R/AC$$

where A, B, and C are binomials with the coefficients a and a', b and b', c and c', and P, Q, and R are the determinants

$$\begin{vmatrix} a & a' \\ b & b' \end{vmatrix} \quad \begin{vmatrix} b & b' \\ c & c' \end{vmatrix} \quad \begin{vmatrix} a & a' \\ c & c' \end{vmatrix}$$

For example,

$$\frac{17}{5x^2+13xy-6y^2}+\frac{18}{5x^2-22xy+8y^2}=\frac{-1}{x^2-xy-12y^2}$$

WILLIAM R. RANSOM, *Tufts University*

ERRATA

Errata in article on "Rudiments of Probability Theory," Oct. 1960 issue. A couple of minor typographical errors will be obvious. In addition, the symbols got inverted in the middle of formula (5), page 559, and after P at top of page 560; also, at the top of page 566, the n slipped out of position in three places and the last coefficient should read C_{n-x}^{n}.

JOSEPH MAYER

CREATIVE ABILITY RELATED TO HUMOR

A child's C.Q. (creativity quotient) is related to his sense of humor. Research by Prof. Jacob. W. Getzels and Prof. Philip W. Jackson of the University of Chicago points to development of a "creativity quotient" similar to the I.Q. system of ratings now in use.

For their research on giftedness, they used a group of about 500 adolescents in the University of Chicago Laboratory School from the sixth grade to the end of the senior year in high school. They found that the emphasis on sense of humor is so marked that it is the one characteristic that sharply sets apart the high-creativity group from all other groups. Their research also disclosed that teachers prefer the high I.Q. child to the child with the high C.Q. The highly creative child studied was selected only if he was not in the top 20% in I.Q. The high I.Q. child and the high C.Q. child were equally superior in school achievement to the student population as a whole.

PROBLEM DEPARTMENT

Conducted by Margaret F. Willerding

San Diego State College, San Diego, Calif.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution or proposed problem sent the Editor should have the author's name introducing the problem or solution *as on the following pages.*

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Solutions should be in typed form, double spaced.

2. Drawings in India ink should be on a separate page from the solution.

3. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

4. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

2735. *C. W. Trigg, Los Angeles, Calif.*

2736. *Proposed by D. Moody Bailey, Princeton, W. Va.*

P is a point within triangle ABC and rays from A, B, and C through P meet the opposite sides a, b, and c in points D, E, and F, respectively. If

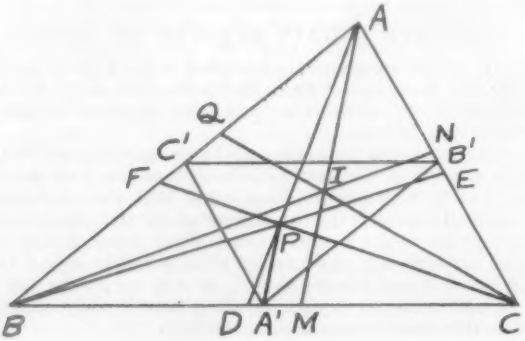
$$AF/FB=(a+c)/(b+c), \qquad BD/DC=(a+b)/(a+c), \qquad CE/EA=(b+c)/(a+b),$$

show that P is the incenter of the medial triangle $A'B'C'$ of triangle ABC.

Solution by C. W. Trigg, Los Angeles City College

The ratio of similitude of the triangles $A'B'C'$ and ABC is 1:2, so the distance from the vertex A' to the center of the Spieker circle (the incircle of the medial triangle) is $PA'=\frac{1}{2}AI$, where I is the incenter of ABC.

Let the angle bisectors from A, B, and C meet the opposite sides in M, N, and Q, respectively. Then $AQ/QB=b/a$ and $AN/NC=c/a$. By a corollary of Ceva's Theorem, $AI/IM=AQ/QB+AN/NC=b/a+c/a=(b+c)/a$. It follows that $AI/AM=(b+c)/(a+b+c)$.



Since $AB'A'C'$ is a parallelogram, the angle bisectors PA' and AM are parallel. Then

$$DA'/DM = PA'/AM = \tfrac{1}{2}(AI/AM) = (b+c)/2(a+b+c).$$

Hence

$$DA'/A'M = (b+c)/(2a+b+c).$$

Now

$$c/b = BM/MC = (BA'+A'M)/(A'C-A'M) = (a/2+A'M)/(a/2-A'M).$$

Therefore

$$(c-b)/(c+b) = 2A'M/a, \quad \text{so} \quad A'M = a(c-b)/2(c+b).$$

Then

$$DA' = [a(c-b)/2(c+b)][(b+c)/(2a+b+c)] \quad \text{and}$$

$$\frac{BD}{DC} = \frac{BA'-DA'}{A'C+DA'} = \frac{a/2-a(c-b)/2(2a+b+c)}{a/2+a(c-b)/2(2a+b+c)} = \frac{a+b}{a+c}.$$

From considerations of symmetry, $CE/EA = (b+c)/(b+a)$, and

$$AF/FB = (c+a)/(c+b).$$

Hence, $(AF/FB)(BC/CD)(CE/EA) = 1$, so by Ceva's Theorem and its converse, lines which divide the sides in the given ratios are concurrent at the center of the Spieker circle.

2737. *Proposed by C. W. Trigg, Los Angeles, Calif.*

The familiar "prime" formula $f(n) = n^2-n+41$, has many composite values for $n \geq 41$. Find the value of n for which $f(n)$ is palindomic with the sum of its two prime factors equal to 440.

Solution by W. R. Talbot, Jefferson City, Mo.

Let $f(n) = p \cdot q$ where p and q are primes and $q = 440-p$. If $p = 2$ or 5, q is not prime. Then p ends in 1, 3, 7 or 9 and the corresponding endings of q are 9, 7, 3 or 1. Then p ends in 3, q in 7, and $f(n)$ in 1, or p ends in 1, q in 9, and $f(n)$ in 9.

For a given N, the maximum product cd where $N = c+d$, is given when $c = d = N/2$. Since $(440/2)^2 = 48400$, the largest palindrome is lbcbl. The impossibility of $1b1$ and $9b9$ as products of $p(440-p)$ is apparent. The forms $1bb1$ and $9bb9$ have the factor 11 making the other factor 429 which is not prime.

From $20 \cdot 420 = 8400$ and $60 \cdot 380 = 22\,800$, we see $20 < p < 60$. Only $p = 43$ in this range pairs with a prime, 397. The product $43 \cdot 397 = 17071$, the palindrome for which $n = 131$.

Solutions were also submitted by Enoch J. Haga, Vacaville, Calif.; and the proposer.

2738. *Proposed by D. Moody Bailey, Princeton, W. Va.*

P is the center of the nine point circle of triangle ABC. Rays from the vertices A, B, and C are drawn through P meeting the opposite sides a, b, and c at points D, E, and F respectively. Determine the value of the ratios

$$\frac{BD}{DC}, \quad \frac{CE}{EA}, \quad \text{and} \quad \frac{AF}{FB}$$

in terms of the sides of triangle ABC.

Solution by the proposer

Let us use Fig. 1 to establish some preliminary values needed for the solution of the problem. Here O is the circumcenter of triangle ABC and rays AO, BO, and

CO meet sides BC, CA, and AB at points G, H, and I respectively. It is not difficult to show that $\angle BAG = 90° - \angle C$ and $\angle GAC = 90° - \angle B$. Accordingly

$$\frac{BG}{GC} = \frac{c \text{ sine } (90° - \angle C)}{b \text{ sine } (90° - \angle B)} = \frac{c \text{ cosine } C}{b \text{ cosine } B}.$$

Using the well known equations $c^2 = a^2 + b^2 - 2ab$ Cos C and $b^2 = a^2 + c^2 - 2ac$ Cos B, we solve for Cos C and Cos B and substitution then gives

$$\frac{BG}{GC} = \frac{c^2(a^2 + b^2 - c^2)}{b^2(a^2 + c^2 - b^2)}.$$

In a similar fashion we obtain

$$\frac{CH}{HA} = \frac{a^2(b^2 + c^2 - a^2)}{c^2(a^2 + b^2 - c^2)} \quad \text{and} \quad \frac{AI}{IB} = \frac{b^2(a^2 + c^2 - b^2)}{a^2(b^2 + c^2 - a^2)}.$$

In this form the ratios are cumbersome for later computation. We therefore let $a^2(b^2 + c^2 - a^2) = J$, $b^2(a^2 + c^2 - b^2) = K$, and $c^2(a^2 + b^2 - c^2) = L$. Then

$$(1)\ \frac{BG}{GC} = \frac{L}{K}, \qquad (2)\ \frac{CH}{HA} = \frac{J}{L}, \text{ and } (3)\ \frac{AI}{IB} = \frac{K}{J}.$$

Continuing with Fig. 1, we write

$$\frac{BG}{GC} = \frac{L}{K} \text{ as } \frac{BG}{a - BG} = \frac{L}{K}$$

and solving have

$$(4) \qquad BG = \frac{aL}{K + L}.$$

Considering triangle AGC with transversal BOH, the theorem of Menelaus gives

$$\frac{CH}{HA} \cdot \frac{AO}{OG} \cdot \frac{GB}{BC} = -1 \text{ or } \frac{AO}{OG} = \frac{AH}{HC} \cdot \frac{BC}{BG}.$$

Using (2), (4), and replacing BC by a yields

$$(5) \qquad \frac{AO}{OG} = \frac{K + L}{J}.$$

In Fig. 2 $A'B'C'$ is the medial triangle ABC. It is well known that the nine point center P is the circumcenter of triangle $A'B'C'$. Thus P (Fig. 2) and O (Fig. 1) are homologous points in triangles $A'B'C'$ and ABC. Extend $A'P$ to meet $B'C'$ at G' (Fig. 2). Then

$$\frac{C'G'}{G'B'} \text{ and } \frac{A'P}{PG'}$$

of Fig. 2 must equal

$$\frac{CG}{GB} \text{ and } \frac{AO}{OG}$$

of Fig. 1. Extend AG' (Fig. 2) to meet BC at M and we have

$$\frac{BM}{MC} = \frac{C'G'}{G'B'} = \frac{CG}{GB} = \frac{K}{L}$$

from (1). Rewriting

$$\frac{BM}{MC} = \frac{K}{L} \text{ as } \frac{BM}{a - BM} = \frac{K}{L}$$

and solving yields

$$BM = \frac{aK}{K+L}. \tag{6}$$

Now $MA' = BA' - BM$ and replacing BA' by $a/2$ and substituting for BM from (6) gives

$$MA' = \frac{a(L-K)}{2(K+L)}. \tag{7}$$

Consider triangle $MA'G'$ with transversal APD (Fig. 2). The theorem of Menelaus yields

$$\frac{MD}{DA'} \cdot \frac{A'P}{PG'} \cdot \frac{G'A}{AM} = -1 \quad \text{or} \quad \frac{MD}{DA'} = \frac{G'P}{PA'} \cdot \frac{AM}{AG'}.$$

Substituting the value of GO/OA from (5) for $G'P/PA'$ and noting that AM/AG is equal to 2, we get

$$\frac{MD}{DA'} = \frac{2J}{K+L} \tag{8}$$

which may be rewritten as

$$\frac{MD}{MA' - MD} = \frac{2J}{K+L}.$$

Substituting the value of MA' given in (7) and solving yields

$$MD = \frac{aJ(L-K)}{(K+L)(2J+K+L)}. \tag{9}$$

Now $BD = BM + MD$ and using (6) and (9) this becomes

$$BD = \frac{a(J+K)}{(2J+K+L)}. \tag{10}$$

Since $DC = a - BD$, we use (10) and have

$$DC = \frac{a(J+L)}{(2J+K+L)}. \tag{11}$$

From (10) and (11) we finally get

$$\frac{BD}{DC} = \frac{J+K}{J+L}. \tag{12}$$

Replacing J, K, and L by their original values gives

$$\frac{BD}{DC} = \frac{a^2(b^2+c^2-a^2)+b^2(a^2+c^2-b^2)}{a^2(b^2+c^2-a^2)+c^2(a^2+b^2-c^2)}.$$

In a similar manner it may be shown that

$$\frac{CE}{EA} = \frac{b^2(a^2+c^2-b^2)+c^2(a^2+b^2-c^2)}{b^2(a^2+c^2-b^2)+a^2(b^2+c^2-a^2)}$$

and

$$\frac{AF}{FB} = \frac{c^2(a^2+b^2-c^2)+a^2(b^2+c^2-a^2)}{c^2(a^2+b^2-c^2)+b^2(a^2+c^2-b^2)}.$$

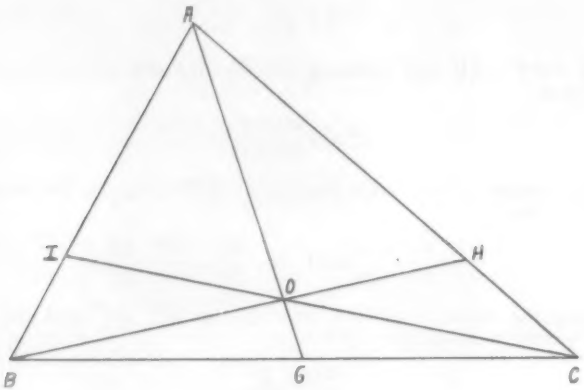


FIG. 1

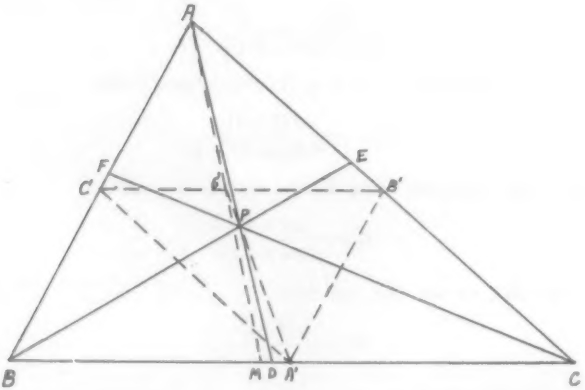


FIG. 2

2739. *Proposed by Donald R. Byrkit, West Chicago, Ill.*

Find Q consecutive perfect squares whose sum is a perfect square, $3 \leq Q \leq 20$.

Solution by C. W. Trigg, Los Angeles City College

E. Lucas (Recherches sur l'analyse indéterminеé, Moulins, 1873, 91) noted that the sum of y consecutive squares may be a square for $y = 2, 11, 23, 24$, but for no further value $1 < y \leq 24$.

Now if $Q = 11$, let x^2 be the middle square, then

$$(x-5)^2+(x-4)^2+\cdots+(x+5)^2=11(x^2+10)=z^2.$$

So we have to solve $x^2+10=11\,W^2$, which may be written in the form

$$(x+1)(x-1)=11(W-1)(W-1).$$

The two smallest solutions of this equation are $(x, W) = (23, 7)$ and $(43, 13)$. Hence two solutions of the problem are:

$$18^2+19^2+\cdots+28^2=77^2,$$

and

$$38^2+39^2+\cdots+48^2=143^2.$$

Solutions were also submitted by Daniel Finkel, Brooklyn, N. Y.; and Brother Felix John, Philadelphia, Pa.

2740. *Taken from More Problematical Recreations.*

If each of the letters A, B, and C represents a particular digit, what is the minimum value of the whole number ABC divided by $A+B+C$? (The answer is not one).

Solution by C. W. Trigg, Los Angeles City College

For any set of three digits, A, B, C, the minimum value will be given if $A<B<C$, A is small, and $A+B+C$ is relatively large. Since zero is not an admissible value for A, the minimum value sought is $189/(1+8+9)$ or $10\frac{1}{2}$.

Solutions were also offered by Enoch J. Haga, Turlock, Calif.; Brother Felix John, Philadelphia, Pa.; and W. R. Talbot, Jefferson City, Mo.

2741. *Proposed by Brother Felix John, Philadelphia, Pa.*

A sphere with a diameter of e units is tangent to the faces of a trihedral angle whose face angles are right angles. Another sphere is tangent to this sphere and to the three faces. Find the radius of the second sphere.

Solution by Leon Bankoff, Los Angeles, Calif.

Let f denote the radius of the second sphere and d the distance of the center of the first sphere from the vertex of the trihedral angle.

Since the line of centers of the spheres passes through the vertex of the trihedral angle, we have

$$(f+e)/(f-e)=d/e=\sqrt{3}$$

or

$$f=e(\sqrt{3}+2)$$

Solutions were also submitted by Charles H. Butler, Kalamazoo, Mich.; B. Pleimann, Garden, Calif., and the proposer.

S-7. No correct solution was submitted.

S-8. No solution was submitted.

STUDENT HONOR ROLL

The Editor will be very happy to make special mention of classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each student contributor will receive a copy of the magazine in which his name appears.

For this issue the Honor Roll appears below.

2741. *Floyd D. Wilder, Bethany Nazarene College, Bethany, Okla.*

PROBLEMS FOR SOLUTION

2761. *Proposed by C. W. Trigg, Los Angeles City College*

TRITONE is divisible by 3 and by 7. Furthermore $T+RIT=$ONE. Find the digits uniquely represented by the latters in the decimal scale.

2762. *Proposed by Floyd D. Wilder, Bethany, Okla.*

If $y=x!$, where $x!$ is defined for all values of x by the gamma function, find dy/dx.

2763. *Proposed by Cecil B. Read, Wichita, Kans.*

Let aa, aaa, represent numbers expressed in decimal notation; i.e., for $a=7$, aa is seventy-seven, not 7×7, and $aaa=777$, not 7^3. For $a=9$,

$$999<99^9<9^{99}<9^{9^9}$$

but for $a=2$,

$$222<22^2<2^{22}<2^{2^2}.$$

Determine other than by trial and error, the least value of a for which

$$aaa<aa^a<a^{aa}<a^{a^a}.$$

Generalize to a number system with base k.

2764. *Proposed by Brother Felix John, Philadelphia, Pa.*

There are three numbers in geometrical progression such that three times the first, twice the second, and once the third, taken in order form an arithmetical series; and also the first, the second increased by 8, and the third, taken in order, form an arithmetical series. What are the numbers?

2765. *Proposed by Howard D. Grossman, New York, N. Y.*

Given $a+b+c=1$; $a^2+b^2+c^2=2$; $a^3+b^3+c^3=3$. Find $a^4+b^4+c^4$.

2766. Taken from *Mathematical Pie.*

Find the fallacy in: if $N>n$, $\log N>\log n$, $\frac{1}{2}>\frac{1}{4}$; therefore $\log\frac{1}{2}>\log\frac{1}{4}$; therefore $\log\frac{1}{2}>\log(\frac{1}{4})^2$; therefore $\log\frac{1}{2}>2(\log\frac{1}{2})$. Therefore $1>2$!

RADIOACTIVE SEEDS IN PITUITARY CHECK BREAST CANCER SPREAD

Hope for victims of rapidly spreading breast cancer is promised from experiments in which tiny, radioactive metallic seeds are planted in the pituitary gland.

An evaluation of a new and relatively safe procedure as a means of controlling this form of breast cancer is being carried out by a surgeon-endocrinologist-radiologist team at the University of California at Los Angeles Medical Center.

Breast cancer, which spreads to the lymph glands and other parts of the body, requires certain hormones whose production is triggered by the pituitary in several glands, including the adrenals and ovaries.

The standard means of denying these hormones to the cancer is actual surgical removal of the pituitary gland, which has brought relief to some victims. The new method is being compared with the standard method in the current study.

Radioactive yttrium seeds can be placed in the pituitary with the help of precise instrumentation and techniques developed at UCLA.

The tiny metallic seeds are planted via a hollow needle that is inserted through the nose and sinus into the gland. The radioactivity of the seed destroys the gland.

The new technique has been used with 17 cases to date and continues to show promise.

Books and Teaching Aids Received

NEW DEVELOPMENTS IN HIGH SCHOOL SCIENCE TEACHING. Paper. 15×23 cm. 108 pages. 1960. National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington, D. C. Price $1.50.

BIENNIAL SURVEY OF EDUCATION IN THE UNITED STATES, 1945–56. Paper. 23×15 cm. 14 pages. 1960. U. S. Department of Health, Education, and Welfare, Office of Education. Washington, D.C.

MANAGEMENT OF LEARNING. Paper. 14×23 cm. 37 pages. 1960. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

A PRIMER ON WATER, by Luna B. Leopoid and Walter B. Langbein. Paper. 20×26 cm. 50 pages. 1960. U. S. Department of the Interior, Geological Survey, Washington 25, D. C.

THINGS TO DO IN SCIENCE AND CONSERVATION, by Byron L. Ashbaugh and Muriel Beuschlein. Cloth. 14×23 cm. 163 pages. 1960. The Interstate Printers and Publishers, 19–27 North Jackson Street, Danville, Illinois. Price $2.50.

INTRODUCTION TO MODERN ALGEBRA, by John L. Kelley. Paper. 12.5×20 cm. 210 pages. D. Van Nostrand Company, Inc., 120 Alexander Street, Princeton, New Jersey. Price $2.75.

THE SPACE GUIDEBOOK, by William J. Weiser. Cloth. 20×13 cm. 322 pages 1960. Coward-McCann, Inc., 210 Madison Ave., New York, New York. Price $4.50.

HEXAOLOGY, by William E. Waller. Cloth. 20×13 cm. 171 pages. 1960. Vantage Press, Inc., 120 West 31st Street, New York 1, New York. Price $3.50.

FREE AND INEXPENSIVE EDUCATIONAL AIDS, by Thomas J. Pepe, *Superintendent of Schools, Southbury, Connecticut*. Paper. 20.5×13 cm. 289 pages. 1960. Dover Publications, Inc., 180 Varick Street, New York 14, New York. Price $1.35.

FIRST MEN IN SPACE, by Erik Bergaust. Cloth. 26.5×17.5 cm. 47 pages. 1960. G. P. Putnam's Sons, 210 Madison Ave. New York, New York. Price $2.50.

EDUCATION IN THE JUNIOR HIGH SCHOOL YEARS, by James Bryant Conant. Paper. 14×22 cm. 46 pages. 1960. Educational Testing Service, 20 Nassau Street, Princeton, New Jersey. Fifty cents a copy, or three copies for one dollar.

ALL THE SOUNDS WE HEAR, by Lee Nelson. Cloth. 19×25 cm. 40 pages. 1960. The Steck Company Publishers, Austin, Texas. Price $1.75.

THE VOCABULARY OF GENERAL SCIENCE AT THE EIGHTH GRADE LEVEL, by Sister Mary Ambrose Didier, M.A., *Sisters of St. Francis of Mary Immaculate, Joliet, Illinois*. Paper. 13.5×23 cm. 80 pages. 1960. The Catholic University of America Press, 620 Michigan Avenue, N.E., Washington 17, D. C. Price $1.50.

HARVEST AND HARVESTING THROUGH THE AGES, by N. E. Lee. Cloth. 13×21.5 cm. 208 pp. 1960. Cambridge University Press, 32 East 57th Street, New York 22, N. Y. Price $2.95.

EDUCATORS GUIDE TO FREE FILMSTRIPS. Twelfth and twentieth annual edition, 1960. Paper. Both 27×21.5 cm. Twelfth edition 163 pages. Twentieth edition. 639 pages. Educators Progress Service, Randolph, Wisconsin.

STAR '60 SELECTED PAPERS ON SCIENCE TEACHING, edited by Abraham Raskin, *Hunter College, New York City*. Paper. 21×28 cm. 64 pages. 1960. National Science Teachers Association, 1201 Sixteenth Street, N.W., Washington, D. C. Price $1.00.

THE EXPERIMENTAL COLLEGE, by Winslow R. Hatch. Paper. 15×23 cm. 13 pages. 1960. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

EDUCATORS GUIDE TO FREE SCIENCE MATERIALS, compiled and edited by Mary Horkheimer Saterstrom. Paper. 20.5×27.5 cm. 298 pages. 1960. Educators Progress Service, Randolph, Wisconsin. Price $6.25.

USING MODERN KNOWLEDGE TO TEACH EVOLUTION IN HIGH SCHOOL. Paper. 14.5×23 cm. 36 pages. 1960. The Graduate School of Education, The University of Chicago, Chicago 37, Illinois.

SCIENCE STUDY SERIES. All paper. All 9.5×18 cm. 1960. Doubleday & Company, 575 Madison Avenue, New York 22, New York. Price for each book 95¢.
PASTEUR AND MODERN SCIENCE, by Rene Dubos. 157 pages.
MICHELSON AND THE SPEED OF LIGHT, by Bernard Jaffe. 197 pages.
THE UNIVERSE AT LARGE, by Hermann Bondi. 154 pages.
ACCELERATORS, by Robert R. Wilson and Raphael Littauer. 196 pages.
THE WATERSHED, by Arthur Koestler. 280 pages.

BASIC MATHEMATICS FOR ELECTRONICS, by Nelson M. Cooke. Cloth. 14.5×23 cm. 679 pages. 1960. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $7.50.

EDUCATORS GUIDE TO FREE TAPES, SCRIPTS, AND TRANSCRIPTIONS. Paper. 20×27.5 cm. 203 pages. Seventh Annual Edition 1961. Educators Progress Service, Randolph, Wisconsin.

PHYSICS, developed by The Physical Science Study Committee of Educational Services Incorporated. Cloth. 18×25.5 cm. 656 pages. D. C. Heath and Company, Boston 16, Massachusetts. Price $5.48.

DICTIONARY OF WORD ROOTS AND COMBINING FORMS, by Donald J. Borror. Paper. 11.5×18 cm. 134 pages. 1960. N-P Publications, Palo Alto, California. Price $2.00.

THE EXPLORATION OF SPACE, by Arthur C. Clarke. Paper. 10×18 cm. 192 pages. Fawcett World Library, 67 West 44th Street, New York 36, New York. Price 50¢.

THE TEACHING OF SECONDARY MATHEMATICS, by Charles H. Butler, *Western Michigan University* and F. Lynwood Wren, *San Fernando Valley State College*. Cloth. 15×23 cm. Pages ix+624. 1960. McGraw-Hill Book Company, Inc. 330 West 42nd Street, New York 36, New York. Price $7.50.

THE WORLD OF PHYSICS, by Arthur Beiser, *New York University*. Cloth. 13.5×21 cm. 286 pages. 1960. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, New York. Price $4.25.

BOX TURTLE LIVES IN ARMOR, by Charles Paul May. Cloth. 13.5×20.5 cm. 47 pages. 1960. Holiday House, 8 West 13th Street, New York 11, New York. Price $2.50.

WONDER-WORKERS OF THE INSECT WORLD, by Hiram J. Herbert, *Columbia University*. Cloth. 12.5×20.5 cm. 160 pages. 1960. E. P. Dutton and Company, 300 Park Ave., South, New York 10, New York. Price $3.00.

FOUNDATIONS OF GEOMETRY AND TRIGONOMETRY, by Howard Levi. Cloth. 14.5×23 cm. 347 pages. 1960. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. Price $7.95.

MAGNETS, by Rocco V. Feravolo. Cloth. 14.5×23 cm. 64 pages. 1960. The Garrard Press, Champaign, Illinois. Price $1.69 net, $2.25 list.

INTRODUCTION TO GEOLOGY, by Alfred Livingston, Jr. Paper. 21×28 cm. 55 pages. 1960. N-P Publications, 850 Hansen Way, Palo Alto, Calif. Price $3.00.

HIGH SCHOOL MATHEMATICS, by Herbert E. Vaughan. Paper. 28.5×20.5 cm. 278 pages. 1960. University of Illinois Press.

The A.R.R.L. ANTENNA BOOK. Paper. 15×24.5 cm. 320 pages. 1960. The American Radio Relay League, Inc. West Hartford, Connecticut. Price $2.00.

PHYSICS: FOUNDATIONS & FRONTIERS, by Gamow & Cleveland. Cloth. 1960. Prentice-Hall, Inc., 70th Fifth Ave., New York 11, New York. Price $7.95.

COOPERATIVE RESEARCH PROJECTS. Paper. 53 pages. 23×14.5 cm. 1960. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

FULBRIGHT AND SMITH-MUNDT ACTS. Paper. 104 pages. 21.5×13.5 cm. 1960. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

A COUNSELOR'S GUIDE. Paper. 67 pages. 14×23 cm. 1960. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

THE SPACE SCIENCE TEACHING HANDBOOK. Paper. 16 pages. 23.5×15.5 cm. 1960. Space Science, 4211 Colie Drive, Silver Spring, Maryland. 25¢ per copy.

ENGINEERING ENROLLMENTS AND DEGREES 1959, by Wayne E. Tolliver, *Educational Statistics Branch* and Henry H. Armsby, *Division of Higher Education*. Paper. 47 pages. 20×26 cm. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

ELEMENTARY DIFFERENTIAL EQUATIONS, by Lyman M. Kells, *U. S. Naval Academy*. Cloth. 23×15 cm. v–x+318 pages. 1960. McGraw-Hill Book Company, Inc., 330 West 42nd Street, New York 36, N. Y. Price $6.25.

SOURCE MATERIALS FOR SECONDARY SCHOOL TEACHERS OF FOREIGN LANGUAGES, by Marjorie C Johnston and Ether M. Eaton. Paper. 26 pages. 26×20 cm. United States Government Printing Office, Washington, D. C. Price 20 cents.

COUNTDOWN FOR DECISION, by John B. Medaris, *U. S. Army, Ret.* Cloth. 21×13.5 cm. vi+303 pages. 1960. G. P. Putnam's Sons, 210 Madison Ave. New York, New York. Price $4.50.

LET'S GO TO A RUBBER PLANT, by Marilyn C. Wilson. Cloth. 20.5×16 cm. 47 pages. 1960. G. P. Putnam's Sons, 210 Madison Ave., New York, New York. Price $1.86 net and $1.95 trade edition.

MOUNTAINS ON THE MOVE, by Marie Halun Bloch. Cloth. 16.5×25.5 cm. 95 pages. 1960. Coward-McCann, Inc., 210 Madison Ave., New York, New York. Price $3.00.

LABORATORIES IN THE CLASSROOM. Paper. 13×20.5 cm. 96 pages. 1960. The Library of Science, 59 Fourth Ave., New York 3, New York. Price $1.45.

LET'S EXPLORE WITH THE ELECTRON, by Alfred Bender. Paper. 20×13 cm. 128 pages. 1960. Sentinel Books, Publishers, Inc., 112 East 19th Street, New York 3, New York. Price $1.00.

MUCH LOVED BOOKS, by James O'Donnell Bennett, Paper. 223 pages. 18×10 cm. 1960. Fawcett Publications, Inc., Greenwich, Conn. 50¢.

SCIENCE STUDY SERIES, All paper. Both 18×10 cm. 1960. Anchor Books, Doubleday & Company, Inc., Garden City, New York.
THE RESTLESS ATOM, by Alfred Romer, 198 pages. 95¢.
HORNS, STRINGS & HARMONY, by Arthur H. Benade, 271 pages. 95¢.

PROBABILITY, by Samuel Goldberg. Cloth. v-ix+322 pages. 21×14 cm. 1960. Prentice-Hall, Inc., Englewood Cliffs, N. J. Trade Edition $7.95. Classroom Adoption $5.95.

FUNDAMENTALS OF COLLEGE ALGEBRA, by William H. Durfee. Cloth. v–xi+250 pages. 24×15 cm. 1960. The Macmillan Company, 60 Fifth Avenue, New York 11, New York. $4.50.

OF MICE, MEN AND MOLECULES, by John H. Heller. Cloth. 176 pages. 1960. 20×13 cm. Charles Scribner's Sons, New York, New York.

GREAT EXPERIMENTS IN BIOLOGY, by Mordecai L. Gabriel and Seymour Fogel. 1955 Paper. v–xiii+317 pages. 23×15 cm. Prentice-Hall, Inc., Englewood Cliffs, N. J.

EVOLUTION: PROCESS AND PRODUCT, by Edward O. Dodson, *University of Ottawa*. Cloth. 23×15 cm. vi–xvi+352 pages. 1960. Reinhold Publishing Corporation, New York, New York. College Edition $5.75. Trade Edition $6.90.

APPLIED BOOLEAN ALGEBRA: AN ELEMENTARY INTRODUCTION, by Franz E. Hohn. 1960. v–xx+139 pages. Paper. 23×15 cm. The Macmillan Company, New York, New York. Price $2.50.

FUNDAMENTALS OF TRANSISTOR PHYSICS, by Irving Gottlieb. 1960. Paper. 146 pages. 14×22 cm. John F. Rider Publisher, Inc., 116 W. 14 Street, New York, N. Y. $3.90.

MATHEMATICS II, by W. K. McNabb. Cloth. iii–xv+350 pages. 23×15 cm. 1959. Banks Upshaw and Company, 703 Browder St., Dallas, Texas.

GRUNDLAGEN DER ANALYSIS, by Edmund Landau. Paper. 172 pages. 1960. Chelsea Publishing Company, New York, N. Y. 20×13 cm. Price $1.95.

A SURVEY OF BASIC MATHEMATICS, by Fred W. Sparks, *Texas Technological College*. Paper. 28×21 cm. 1960. McGraw-Hill Book Company, Inc., New York, N. Y. Price $3.95. v–viii+257 pages.

FACILITIES AND EQUIPMENT FOR SCIENCE AND MATHEMATICS, by Edgar Martin. Paper 1960. 29×23 cm. iii–vi+130 pages. United States Government Printing Office, Washington, D. C. Price $1.00.

GEORGE WESTINGHOUSE, Henry Thomas. Cloth. 128 pages. 20×13 cm. 1960. G. P. Putnam's Sons, 210 Madison Ave., New York, New York. Price $2.50.

FOUNDATIONS OF MODERN BIOLOGY. Paperbound. 28×22 cm. 1960. Prentice-Hall, Inc., Englewood Cliffs, New Jersey.

MOTOR CHARACTERISTICS OF THE MENTALLY RETARDED, by Robert J. Francis and G. Lawrence Rarick, *University of Wisconsin*. Paper. 15×23 cm. 40 pages. 1960. U. S. Department of Health, Education, and Welfare, Office of Education, Washington, D. C.

Book Reviews

EDUCATORS GUIDE TO FREE SCIENCE MATERIALS, compiled and edited by Mary Horkheimer Saterstrom. Paper. 20.5×27.5 cm. 298 pages. 1960. Educators Progress Service, Randolph, Wisconsin. Price $6.25.

Over the years the Educators Progress Service has produced a number of guides to free materials for use by educators. These have included indexes to free published materials, free films, free filmstrips, and other teaching aids. This document is the first edition devoted solely to "science materials."

The first edition indexes and provides information on titles and sources of more than 1000 selected free items for science. These include bulletins, pamphlets, charts, posters, books, films and filmstrips. The publication contains a table of contents giving a curricular classification of the materials indicated, a title index, subject index, source index, a list of items suitable for teachers of science as well as full information on all the materials listed.

It would be impossible of course, for any one reviewer to check the outlines item by item for accuracy or completeness. However, a spot check of 25 listings were made for accuracy and completeness. In the opinion of the reviewer the listings "stood up."

It is difficult for the reviewer to do other than report favorably on the publication. The list of addresses of sources alone seems to suggest that the publication is worth the price. The ideas for developing units at the end could profit by better integration with the basic materials of the listing however. The possibility of an up-to-date annual issue is particularly attractive.

This document might well be available to every science teacher. It should serve to provide materials that are badly needed and save the science teacher much time in obtaining them.

G. G. M.

THE SPACE SCIENCE TEACHING HANDBOOK. Paper. 16 pages. 23.5×15.5 cm. 1960. Space Science, 4211 Colie Drive, Silver Spring, Maryland. 25¢ per copy.

It is generally recognized that the areas of astronomy, geology, and meteorology are among the more neglected in the science programs in the elementary and secondary schools. A number of efforts have been made to improve the situation. *The Space Science Teaching Handbook* is one such effort.

The pamphlet consists of sixteen pages and four chapters in which the possibilities of emphasizing space science in the classroom at science fairs, as part of star parties and in astronomy clubs. The chapters consist chiefly of pleas to emphasize space science with suggestions for materials and activities. Without question the pamphlet will be helpful in an area in which assistance is admittedly small. However, the sections could profit from better integration, less exhortation and more "meat." Without doubt better publications will need to be produced before this area is treated with due emphasis in the science program.

G. G. M.

X-RAYS O.K. FOR TEETH SAYS DENTAL ASSOCIATION

The Council on Dental Research of the ADA said the fraction of diagnostic radiation that reaches the reproductive organs of the body during the course of a dental examination is less than the amount received by each person from natural sources in an entire year, and can have no significant influence on the genetic patterns of succeeding generations.

"YO-YO" MEASURES OCEAN TURBULENCE

A new device that looks like a yo-yo will permit scientists to study and directly measure the turbulent movements in the oceans. Water flows about a paddle-wheel in the device and the movement is recorded automatically.

1961 SUMMER INSTITUTES
SPONSORED BY NSF

The following is a list of the Summer Institutes sponsored by the National Science Foundation. Information and application forms may be obtained by writing to the Director of the Institute. All applications must be postmarked no later than February 15, 1961. For additional information, write directly to the Director of the Institute, *NOT* to the National Science Foundation.

NATIONAL SCIENCE FOUNDATION

SUMMER INSTITUTES

1961

CODE

A	Astronomy	GS	General Science
An	Anthropology	H	History & Philosophy of Science
B	Biology	IT	Isotope Technology
C	Chemistry	M	Mathematics
En	Engineering	P	Physics
ES	Earth Sciences	RB	Radiation Biology
Ge	Geology	S	Statistics

For High School Teachers Only, except as follows:
* For College Teachers Only.
† For High-School and College Teachers.
♯ For Teachers in Technical Institutes and in Technical Curricula in Junior Colleges.

INSTITUTION	DIRECTOR	FIELDS
	Alabama	
†Univ. of Alabama (University)	Dr. Julian D. Mancill	M
Univ. of Alabama (University)	Dr. Julian D. Mancill	B C ES P
Alabama College (Montevallo)	Dr. Paul C. Bailey	B C M P
Auburn Univ.	Dr. Ernest Williams	M
Auburn Univ.	Dr. Ernest Williams	B C GS P
Birmingham-Southern Coll.	Dr. Wiley S. Rogers	B C ES M P
†Tuskegee Institute	Dr. J. H. M. Henderson	RB
Tuskegee Institute	Dr. Lawrence F. Koons	C
	Alaska	
Univ. of Alaska (College)	Prof. W. R. Casmen	C ES M P
	Arizona	
*Univ. of Arizona (Tucson)	Dr. M. R. Bottaccini	En
Univ. of Arizona (Tucson)	Dr. A. H. Steinbrenner	M
Univ. of Arizona (Tucson)	Prof. M. G. Seeley	C P Bot. Zoo.
*Arizona State Univ. (Tempe)	Dr. Gordon L. Bender	B
Arizona State Univ. (Tempe)	Dr. Valentine Galasyn	C P
	Arkansas	
Univ. of Arkansas (Fayetteville)	Dr. Lowell F. Bailey	B C GS P
*Univ. of Arkansas (Fayetteville)	Mr. R. C. Wray	En
Arkansas State Coll. (State Coll.)	Dr. W. W. Nedrow	B C ES M P
	California	
Univ. of Calif. (Berkeley)	Prof. Frantisek Wolf	M

Institution	Director	Fields
Univ. of Calif. (Berkeley)	Mr. Robert A. Rice	B C P
Univ. of Calif. (Berkeley)	Prof. D. C. Bryant	RB
*Univ. of Calif. (Berkeley)	Prof. George Jura	IT
Univ. of Calif. (Berkeley)	Mr. Mario Menesini	B
*Univ. of Calif. (Los Angeles)	Prof. P. K. E. Henrici	Computing
Univ. of Calif. (Los Angeles)	Prof. Clifford Bell	M
Univ. of Calif. (Santa Barbara)	Prof. W. H. Meyer	M
Univ. of Calif. (Santa Barbara)	Dr. J. H. Chilcott	An
†Harvey Mudd Coll. (Claremont)	Prof. Lloyd E. Malm	C
Humboldt State Coll. (Arcata)	Dr. W. M. Lanphere	B C M P
Los Angeles State Coll.	Dr. W. O. Griesel	B
Occidental Coll. (Los Angeles)	Dr. Patrick H. Wells	B
Coll. of the Pacific (Stockton)	Mr. Alexander Vavoulis	C M
Sacramento State College	Prof. Carl E. Ludwig	GS M
San Jose State College	Prof. Max Kramer	M
San Jose State College	Dr. Leonard I. Holder	M
Univ. of Santa Clara	Prof. Alvin M. White	M
Stanford Univ.	Prof. Harold M. Bacon	M
*Stanford Univ.	Prof. H. S. Seifert	Space Technology
	Colorado	
*Univ. of Colo. (Boulder)	Dr. Alec J. Kelso	An
Univ. of Colo. (Boulder)	Prof. C. R. Bitter	Bacteriology
Univ. of Colo. (Boulder)	Dr. R. N. Keller	B C ES M P
Univ. of Colo. (Boulder)	Dr. J. M. Cleveland	P
†Colorado College (Colo. Spr.)	Dr. R. G. Beidleman	B C GS M P
Colo. School of Mines (Golden)	Dr. James L. Hall	C Ge
Colo. State Coll. (Greeley)	Dr. John A. Beel	C
Colo. State Univ. (Ft. Collins)	Dr. John R. Olive	Field Biology
*Colo. State Univ. (Ft. Collins)	Dr. J. R. Barton	En
Colo. State Univ. (Ft. Collins)	Dr. G. H. Splittgerber	C
	Connecticut	
Univ. of Connecticut (Storrs)	Dr. David J. Blick	B C ES P
Cent. Conn. State Coll. (New Britain)	Prof. R. L. Mentzer	B C M P
Wesleyan Univ. (Middletown)	Prof. J. S. Daltry	A B C ES H M P
Yale Univ. (New Haven)	Prof. S. R. Brinkley	B C M P
	Delaware	
Univ. of Delaware (Newark)	Dr. John A. Brown	B C M P
	Dist. of Columbia	
American Univ.	Dr. Leo Schubert	C P
*American Univ.	Dr. Leo Schubert	H
Catholic Univ. of America	Prof. Henry P. Ward	C P
Catholic Univ. of America	Prof. R. W. Moller	M
Georgetown Univ.	Dr. M. W. Oliphant	M
George Washington Univ.	Prof. David Nelson	M
Howard Univ.	Dr. Marie C. Taylor	B RB
	Florida	
Univ. of Fla. (Gainesville)	Dr. W. T. Lippincott	B C M
†Fla. State Univ. (Tallahassee)	Dr. Grace C. Madsen	B
Fla. State Univ. (Tallahassee)	Dr. James Snover	M
Fla. State Univ. (Tallahassee)	Dr. C. W. Edington	RB
Stetson Univ. (DeLand)	Dr. Gene W. Medlin	M

Institution	Director	Fields
	Georgia	
Albany State College	Prof. Alexander A. Hall	B C M P
Atlanta Univ.	Dr. K. A. Huggins	B C M
*Emory Univ. (Atlanta)	Prof. Henry Sharp, Jr.	M
Emory Univ. (Atlanta)	Dr. William H. Jones	C
Univ. of Georgia (Athens)	Dr. T. H. Whitehead	A B C M P
Ga. Inst. of Tech. (Atlanta)	Dr. J. A. Stanfield	C M P
Ga. Southern Coll. (Collegeboro)	Dr. B. J. Bogitsh	B C M
	Hawaii	
†Univ. of Hawaii (Honolulu)	Prof. S. C. Hsiao	RB
Univ. of Hawaii (Honolulu)	Dr. A. J. Bernatowicz	B M P Phys. Science
	Idaho	
Univ. of Idaho (Moscow)	Prof. K. A. Bush	M
Univ. of Idaho (Moscow)	Dr. Edgar H. Grahn	B C ES M P
	Illinois	
Bradley Univ. (Peoria)	Dr. A. W. McGaughey	B C M P
Eastern Ill. Univ. (Charleston)	Dr. Weldon N. Baker	C P Bot. Zoo.
#Univ. of Illinois (Urbana)	Prof. J. S. Dobrovolny	En M
Univ. of Illinois (Urbana)	Prof. Max Beberman	M
Univ. of Illinois (Urbana)	Prof. A. M. Hartley	C
Ill. Inst. of Tech. (Chicago)	Dr. Haim Reingold	M P
*Ill. Inst. of Tech. (Chicago)	Dr. Peter Chiarulli	En
Ill. Wesleyan Univ. (Bloomington)	Dr. W. W. Wantland	B C M P
Knox College (Galesburg)	Dr. Rothwell Stephens	M
Knox College (Galesburg)	Dr. Herbert Priestley	C P
*Northwestern Univ. (Evanston)	Prof. E. J. Taaffe	ES
†Northwestern Univ. (Evanston)	Prof. E. H. C. Hildebrandt	M
Southern Ill. Univ. (Carbondale)	Prof. Morton R. Kenner	M
Southern Ill. Univ. (Carbondale)	Dr. I. L. Shechmeister	B
	Indiana	
DePauw Univ. (Greencastle)	Dr. Donald J. Cook	GS M
Earlham Coll. (Richmond)	Dr. Laurence E. Strong	C
Earlham Coll. (Richmond)	Dr. Murvel R. Garner	B
Ind. State Teachers Coll. (Terre Haute)	Dr. John C. Hook	GS
Indiana Univ. (Bloomington)	Mrs. Marie S. Wilcox	M
Indiana Univ. (Bloomington)	Dr. T. G. Perry	ES
Indiana Univ. (Bloomington)	Dr. Paul Weatherwax	B
Indiana Univ. (Bloomington)	Dr. R. B. Fischer	C
*Indiana Univ. (Bloomington)	Dr. Wayne R. Lowell	ES
Indiana Univ. (Bloomington)	Prof. L. S. McClung	B Bacteriology
Univ. of Notre Dame	Dr. Arnold E. Ross	M
Univ. of Notre Dame	Prof. Emil T. Hofman	C
Purdue Univ. (Lafayette)	Dr. M. Wiles Keller	M
Purdue Univ. (Lafayette)	Dr. John E. Christian	RB
Purdue Univ. (Lafayette)	Dr. J. D. Novak	B
Purdue Univ. (Lafayette)	Prof. R. W. Lefler	P
Purdue Univ. (Lafayette)	Prof. D. A. Davenport	C
Purdue Univ. (Lafayette)	Prof. R. W. Lefler	P
Valparaiso Univ.	Prof. A. E. Hallerberg	M
	Iowa	
Drake Univ. (Des Moines)	Dr. R. A. Rogers	B

Institution	Director	Fields
Iowa State Teachers Coll. (Cedar Falls)	Dr. Irvin H. Brune	M
Iowa State Teachers Coll. (Cedar Falls)	Dr. Dorothy C. Matala	ES
Iowa State Teachers Coll. (Cedar Falls)	Dr. Dorothy C. Matala	B
*Iowa State Univ. (Ames)	Prof. T. A. Bancroft	S
Iowa State Univ. (Ames)	Dr. O. C. Kreider	B C ES M P
*Iowa State Univ. (Ames)	Dr. Glenn Murphy	En
	Kansas	
Ft. Hays Kansas State Coll. (Hays)	Dr. Ward L. Sims	B C ES P
Univ. of Kansas (Lawrence)	Dr. Edward I. Shaw	RB
†Univ. of Kansas (Lawrence)	Prof. R. N. Bradt	M
Kansas State Coll. of Pittsburg	Dr. R. G. Smith	B M P
Kansas State Coll. of Pittsburg	Dr. David G. Darry	B ES Phys. Science
Kansas State Teachers Coll. (Emporia)	Dr. Otto M. Smith	B C GS M P
Kansas State Univ. (Manhattan)	Dr. J. R. Chelikowsky	ES
Kansas State Univ. (Manhattan)	Dr. Leonard E. Fuller	M
Washburn Univ. of Topeka	Prof. Laura Z. Greene	M
	Kentucky	
Univ. of Kentucky (Lexington)	Dr. J. M. Carpenter	B C M P
Murray State College	Dr. Alfred Wolfson	B C ES M P
West Ky. State Coll. (Bowling Green)	Dr. Ward C. Sumpter	B C ES M P
	Louisiana	
Grambling Coll.	Dr. Archie L. Lacey	B ES M Phys. Science
*La. Poly. Inst. (Ruston)	Dr. M. A. Nobles	En M
La. State Univ. (Baton Rouge)	Prof. B. E. Mitchell	M
*La. State Univ. (Baton Rouge)	Prof. H. D. Richardson	IT
Northwestern State Coll. (Natchitoches)	Dr. George A. Stokes	ES M P
Southern Univ. (Baton Rouge)	Dr. Leon R. Roddy	B C ES M P
Univ. of Southwestern La. (Lafayette)	Dr. James R. Oliver	ES
Univ. of Southwestern La. (Lafayette)	Dr. James R. Oliver	M
Tulane Univ. (New Orleans)	Dr. Joseph E. Gordon	M
*Tulane Univ. (New Orleans)	Dr. J. K. Hampton, Jr.	RB
	Maine	
Bowdoin Coll. (Brunswick)	Prof. R. L. Korgen	M
Bowdoin Coll. (Brunswick)	Prof. A. H. Gustafson	B
Bowdoin Coll. (Brunswick)	Prof. S. E. Kamerling	C
Bowdoin Coll. (Brunswick)	Prof. Noel C. Little	RB
*Bowdoin Coll. (Brunswick)	Prof. D. E. Christie	M
Colby Coll. (Waterville)	Dr. J. W. Combellack	B C ES M P
Univ. of Maine (Orono)	Prof. S. H. Kimball	M
	Maryland	
Johns Hopkins Univ. (Baltimore)	Prof. W. K. Morrill, Sr.	M
Univ. of Mo. (College Park)	Prof. Stanley B. Jackson	M
Univ. of Mo. (College Park)	Dr. J. R. C. Brown	B C P
Morgan State Coll. (Baltimore)	Prof. Thomas P. Fraser	B C ES M P
	Massachusetts	
Boston Coll.	Rev. W. G. Guindon, S.J.	P
Boston Coll.	Rev. S. J. Bezuszka, S.J.	M
†Clark Univ. (Worcester)	Dr. John S. Stubbe	M
Coll. of the Holy Cross (Worcester)	Rev. J. J. MacDonnell, S.J.	M

Institution	Director	Fields
Coll. of the Holy Cross (Worcester)	Rev. J. W. Flavin, S.J.	B C P
Simmons Coll. (Boston)	Dr. P. M. Richardson	B
†Tufts Univ. (Medford)	Prof. M. Kent Wilson	C
Tufts Univ. (Medford)	Prof. M. Kent Wilson	C M P
Worcester Polytechnic Inst.	Prof. Richard F. Morton	C M P
	Michigan	
Central Mich. Univ. (Mt. Pleasant)	Dr. Carl A. Scheel	B
Central Mich. Univ. (Mt. Pleasant)	Prof. Lester H. Serier	M
Univ. of Detroit	Dr. E. L. Henderson	V C P
Eastern Mich. Univ. (Ypsilanti)	Dr. James M. Barnes	B C ES M P
Hope Coll. (Holland)	Dr. Jay E. Folkert	B C M
*Univ. of Mich. (Ann Arbor)	Dr. Melvin Levine	RB
Univ. of Mich. (Ann Arbor)	Prof. Joseph N. Payne	M
*Univ. of Mich. (Ann Arbor)	Prof. Lloyd Brownell	IT
Mich. Coll. of Mining & Tech. (Houghton)	Dr. Donald G. Yerg	ES P
Mich. State Univ. (East Lansing)	Dr. Sherwood Haynes	P
†Mich. State Univ. (East Lansing)	Dr. Wayne Taylor	C M P
Mich. State Univ. (East Lansing)	Dr. T. Wayne Porter	B
Northern Mich. Coll. (Marquette)	Dr. Lucian F. Hunt	B C M P
Wayne State Univ. (Detroit)	Prof. Karl W. Folley	M
Wayne State Univ. (Detroit)	Dr. Walter Chavin	RB
*Western Mich. Univ. (Kalamazoo)	Dr. Haym Kruglak	P
Western Mich. Univ. (Kalamazoo)	Dr. James H. Powell	M
Western Mich. Univ. (Kalamazoo)	Dr. George G. Mallinson	C ES P
	Minnesota	
Carleton Coll. (Northfield)	Prof. R. T. Mathews	A Ge
Carleton Coll. (Northfield)	Prof. Kenneth W. Wegner	M
Macalester Coll. (St. Paul)	Prof. Russell B. Hastings	GS
Univ. of Minnesota (St. Paul)	Dr. F. A. Spurrell	RB
Univ. of Minnesota (Minneapolis)	Prof. Frank Verbrugge	C M P
Univ. of Minnesota (Minneapolis)	Dr. David W. French	B
St. Cloud State Coll.	Dr. Harold Hopkins	B C GS P
Coll. of St. Thomas (St. Paul)	Dr. Martin Allen	C
	Mississippi	
†Univ. of Miss. (University)	Dr. Noel A. Childress	B C M P
Miss. Southern Coll. (Hattiesburg)	Dr. J. Fred Walker	B C M
†Miss. State Univ. (State College)	Dr. Clyde Q. Sheely	B C M P
	Missouri	
Central Coll. (Fayette)	Dr. N. C. Nielsen	C
Univ. of Missouri (Columbia)	Dr. R. F. Brooks	B
*Univ. of Missouri (Columbia)	Prof. Karl H. Evans	En
Univ. of Missouri (Columbia)	Dr. Wesley J. Dale	C P
Univ. of Missouri (Columbia)	Dr. Paul B. Burcham	M
Mo. School of Mines & Metallurgy (Rolla)	Dr. Harold Q. Fuller	C M P
St. Louis Univ.	Prof. Francis Regan	M
S.W. Mo. State Coll. (Springfield)	Dr. C. V. Fronabarger	M
	Montana	
†Montana State Coll. (Bozeman)	Dr. L. O. Binder, Jr.	C
Montana State Univ. (Missoula)	Dr. William M. Myers	M

Institution	Director	Fields
Montana State Univ. (Missoula)	Dr. Gorond B. Castle	RB
Montana State Univ. (Missoula)	Dr. James W. Gebhart	B
Nebraska		
Univ. of Nebraska (Lincoln)	Dr. W. E. Mientka	M
Univ. of Nebraska (Lincoln)	Dr. J. R. Demuth	B C H P
†Nebraska Wesleyan Univ. (Lincoln)	Dr. W. R. French, Jr.	P
Nevada		
Univ. of Nevada (Reno)	Dr. R. N. Tompson	M
New Hampshire		
Univ. of New Hampshire (Durham)	Prof. H. A. Iddles	C
Univ. of New Hampshire (Durham)	Dr. Shepley L. Ross	M
New Jersey		
Fairleigh Dickinson Univ. (Teaneck)	Dr. Dolores E. Keller	C GS P
Montclair State Coll. (Upper Montclair)	Dr. Max A. Sobel	M
Princeton Univ.	Mr. J. G. Bradshaw	P
†Princeton Univ.	Mr. J. G. Bradshaw	M
Rutgers, State Univ. (New Brunswick)	Dr. Richard K. Olsson	ES
†Rutgers, State Univ. (New Brunswick)	Dr. Emory P. Starke	M
Rutgers, State Univ. (New Brunswick)	Dr. R. M. Manganelli	B C
Rutgers, State Univ. (New Brunswick)	Dr. R. L. Sells	P
Rutgers, State Univ. (New Brunswick)	Prof. P. G. Pearson	B
Seton Hall Univ. (South Orange)	Prof. F. L. Lynch, Jr.	M P
Stevens Inst. of Tech. (Hoboken)	Prof. R. H. Seavy	C M P
*Stevens Inst. of Tech. (Hoboken)	Prof. R. H. Seavy	En
New Mexico		
Eastern New Mexico Univ. (Portales)	Dr. Ruth B. Thomas	B C ES M P
Univ. of New Mexico (Albuquerque)	Dr. Loren D. Potter	RB
Univ. of New Mexico (Albuquerque)	Prof. Frank C. Gentry	M
New Mexico Highlands Univ. (Las Vegas)	Dr. Vera Usdin	Biophys Biochem.
*New Mexico Coll. of A & M Arts (University Park)	Dr. E. L. Cleveland	M
New York		
Adelphi Coll. (Garden City)	Dr. H. A. Robinson	C M RB
Alfred Univ.	Prof. E. G. Ogden	B C Ge P
American Museum of Nat. History (New York)	Mr. Bruce C. Hunter	B ES
Brooklyn Coll.	Prof. James Singer	M
Univ. of Buffalo	Prof. Harriet F. Montague	M
City Coll. (New York)	Prof. Chester B. Kremer	C M P
Clarkson Coll. of Tech. (Potsdam)	Dean F. G. Lindsey	C M P
Colgate Univ. (Hamilton)	Dr. Oran B. Stanley	B C ES P
Colgate Univ. (Hamilton)	Dr. Carl Munshower	M
Teachers Coll. Columbia Univ. (New York)	Prof. F. L. Fitzpatrick	B Phys. Science
Cornell Univ. (Ithaca)	Prof. M. L. Nichols	C
Cornell Univ. (Ithaca)	Prof. R. W. Shaw	ES Space Science
Fordham Univ. (New York)	Dr. F. L. Canavan, S.J.	P
Fordham Univ. (New York)	Rev. Henry F. DeBaggis	M
Hamilton Coll. (Clinton)	Prof. Brewster H. Gere	M

Institution	Director	Fields
Hunter Coll. (New York)	Prof. J. H. Bushey	M
*Rensselaer Poly. Inst. (Troy)	Prof. A. A. K. Booth	Reactor Physics
*Univ. of Rochester	Dr. John B. Hursh	RB
Univ. of Rochester	Dr. John J. Montean	M
Univ. of Rochester	Dr. John J. Montean	C
Univ. of Rochester	Dr. John J. Montean	P
State Univ. Coll. of Ed. (Albany)	Dr. Edgar W. Flinton	B C P
State Univ. Coll. of Ed. (Oneonta)	Dr. M. Ira Dubins	ES
State Univ. Coll. of Ed. (Potsdam)	Dr. Alexander G. Major	B C ES M P
*Syracuse Univ.	Dr. M. W. Jennison	RB
Syracuse Univ.	Prof. Robert B. Davis	M
Syracuse Univ.	Dr. W. R. Fredrickson	C P
Syracuse Univ.	Dr. John G. Burdick	B
Union Coll. (Schenectady)	Dr. D. K. Baker	B C ES M P
Vassar Coll. (Poughkeepsie)	Prof. A. Scott Wartnin, Jr.	ES
Yeshiva Univ. (New York)	Dean Abe Gelbart	M
	North Carolina	
*Duke Univ. (Durham)	Dr. Harold J. Humm	B
Duke Univ. (Durham)	Dr. Thomas D. Reynolds	B C M P
A. & T. Coll. of N. C. (Greensboro)	Dr. G. A. Edwards	C M
A. & T. Coll. of N. C. (Greensboro)	Dr. G. A. Edwards	B C P
*Univ. of N. C. (Chapel Hill)	Dr. H. D. Crockford	C
Univ. of N. C. (Chapel Hill)	Prof. Roy L. Ingram	ES
Univ. of N. C. (Chapel Hill)	Prof. Edward A. Cameron	B C M P
N. C. Coll. at Durham	Dr. W. H. Robinson	B C M
*N. C. State Coll. (Raleigh)	Dr. H. F. Robinson	Genetics
St. Augustine's Coll. (Raleigh)	Dr. Jeffery Gipson	B C ES P
Wake Forest Coll. (Winston-Salem)	Prof. Ivey C. Gentry	B C M P
	North Dakota	
Univ. of N. D. (Grand Forks)	Prof. J. D. Henderson	A C Ge M P Meteorology
N. D. Agricultural Coll. (Fargo)	Dr. F. L. Minnear	C M P Bot.
	Ohio	
Antioch Coll. (Yellow Springs)	Dr. James F. Corwin	B C ES M P
Baldwin-Wallace Coll. (Berea)	Prof. Dean L. Robb	M
Bowling Green State Univ.	Dr. Bruce R. Vogeli	M
Case Inst. of Tech. (Cleveland)	Prof. Paul E. Guenther	M
Central State Coll. (Wilberforce)	Dr. B. H. Johnson	B C
Univ. of Cincinnati	Prof. H. David Lipsich	M
Univ. of Dayton	Prof. K. C. Schraut	M
Kent State Univ.	Dr. Kenneth B. Cummins	M
Kenyon Coll. (Gambier)	Dr. E. S. Graham	C
Miami Univ. (Oxford)	Dr. Bruce V. Weidner	C Ge P Bot. Zoo.
Oberlin College	Prof. Wade Ellis	M
Ohio State Univ. (Columbus)	Prof. Robert C. Fisher	M
Ohio State Univ. (Columbus)	Dr. John S. Richardson	B C ES GS P RB
Ohio Univ. (Athens)	Dr. L. P. Eblin	M Phys. Science
Ohio Wesleyan Univ. (Delaware)	Dr. William D. Stull	A B C ES P
Univ. of Toledo	Dr. Archie N. Solberg	B
Western Reserve Univ. (Cleveland)	Dr. W. M. Heston	B C ES M
Wittenberg Univ. (Springfield)	Prof. N. E. Dodson	ES
	Oklahoma	
Univ. of Oklahoma (Norman)	Dr. Horace E. Hoffman	A M

Institution	Director	Fields
*Univ. of Oklahoma (Norman)	Dr. Horace E. Hoffman	IT
*Univ. of Oklahoma (Norman)	Dr. Horace E. Hoffman	H
Univ. of Oklahoma (Norman)	Dr. Horace E. Hoffman	Ge
†Univ. of Oklahoma (Norman)	Dr. Horace E. Hoffman	B ES
Univ. of Oklahoma (Norman)	Dr. Horace E. Hoffman	B C M P
Oklahoma Baptist Univ. (Shawnee)	Dr. J. O. Purdue	GS M
*Oklahoma State Univ. (Stillwater)	Dr. J. H. Boggs	En
Oklahoma State Univ. (Stillwater)	Dr. James H. Zant	M
Southeastern State Coll. (Durant)	Dr. Leslie A. Dwight	M
Southwestern St. Coll. (Weatherford)	Dr. Earl A. Reynolds	C
	Oregon	
Univ. of Oregon (Eugene)	Prof. A. F. Moursund	M
*Univ. of Oregon (Eugene)	Dr. R. W. Castenholz	Marine Biology
Univ. of Oregon (Eugene)	Dr. Robert W. Morris	B C ES P
*Oregon State Coll. (Corvallis)	Dr. A. V. Logan	C
Oregon State Coll. (Corvallis)	Dr. S. E. Williamson	B C ES GS M P
†Oregon State Coll. (Corvallis)	Dr. Albert R. Poole	M
Reed Coll. (Portland)	Dr. Burrowes Hunt	M
Reed Coll. (Portland)	Dr. F. A. Courts	Psychology
Reed Coll. (Portland)	Prof. A. H. Livermore	C
Southern Oregon Coll. (Ashland)	Dr. Irene Hollenbeck	GS
	Pennsylvania	
Allegheny Coll. (Meadville)	Dr. Robert E. Bugbee	A B C ES M P
Bucknell Univ. (Lewisburg)	Dr. Lester Kieft	B C M P
*Bucknell Univ. (Lewisburg)	Prof. Charles H. Coder, Jr.	En
Frank. & Marsh. Coll. (Lancaster)	Dr. Richard I. Weller	P
Frank. & Marsh. Coll. (Lancaster)	Dr. Bernard Jacobson	M
Frank. & Marsh. Coll. (Lancaster)	Dr. John H. Moss	ES
Juniata Coll. (Huntingdon)	Dr. David M. Hercules	C
Lehigh Univ. (Bethlehem)	Prof. Clarence A. Shook	M
Univ. of Pennsylvania (Phila.)	Prof. J. F. Hazel	B C M P
†Phila. Coll. of Pharmacy and Sci.	Dr. Arthur Osol	Radiochemistry
Univ. of Pittsburgh	Dr. John C. Knipp	M
Seton Hill Coll. (Greensburg)	Sister Mary Thaddeus	M
Thiel Coll. (Greenville)	Dr. Bela G. Kolossvary	B C M P
	Puerto Rico	
Catholic Univ. of P. R. (Ponce)	Bro. Joseph W. Stander, S.M.	M
Inter American Univ. (San German)	Dr. Ishael Velez	B GS
Univ. of P. R. (Mayaguez)	Dr. J. A. Ferrer-Monge	RB
Univ. of P. R. (Rio Piedras)	Prof. Augusto Sobonis	M P
Univ. of P. R. (Rio Piedras)	Dr. Mariano Garcia	M
	Rhode Island	
Brown Univ. (Providence)	Prof. Leallyn B. Clapp	C
Brown Univ. (Providence)	Prof. Elmer R. Smith	B
Univ. of R. I. (Kingston)	Dr. Elmer A. Palmatier	B
	South Carolina	
Claflin Coll. (Orangeburg)	Prof. H. D. Smith, Sr.	B C M Education
Clemson Coll.	Dr. F. I. Brownley, Jr.	B C ES M P
Converse Coll. (Spartanburg)	Dr. Walter J. Wyatt	B C P
Furman Univ. (Greenville)	Dr. J. A. Southern	B C P

Institution	Director	Fields
Univ. of S. C. (Columbia)	Dr. W. L. Williams	M
S. C. State Coll. (Orangeburg)	Dean Algernon S. Belcher	M
	South Dakota	
State Univ. of S. D. (Vermillion)	Prof. M. M. Hasse	B C ES GS M P
State Univ. of S. D. (Vermillion)	Dr. C. R. Estee	B C ES M P
S. D. School of Mines & Tech. (Rapid City)	Mr. H. C. Peterson	C Ge M P
S. D. State Coll. (Brookings)	Prof. Kenneth E. Howard	B C M P
	Tennessee	
E. Tenn. State Coll. (Johnson City)	Dr. Lester C. Hartsell	B C M P
Fisk Univ. (Nashville)	Dr. Edward L. Maxwell	B C P
George Peabody Coll. (Nashville)	Dr. H. Craig Sipe	B C ES H M P
Middle Tenn. State Coll. (Murfreesboro)	Dr. J. Eldred Wiser	B C M P
*Oak Ridge Inst. of Nuc. Studies	Dr. Ralph T. Overman	IT
*Oak Ridge Inst. of Nuc. Studies	Dr. Ralph T. Overman	RB
Oak Ridge Inst. of Nuc. Studies	Dr. Ralph T. Overman	Physical Science
Univ. of the South (Sewanee)	Dr. H. Malcolm Owen	B C H M P Radioisotope
Univ. of Tenn. (Knoxville)	Prof. Edgar D. Eaves	M
Tenn. A & I State Univ. (Nashville)	Prof. Rutherford M. Adkins	C P
Tenn. Poly. Inst. (Cookeville)	Dr. G. B. Pennebaker	B C M P
	Texas	
Baylor Univ. (Waco)	Dr. Bryce C. Brown	B C M P
E. Texas State Coll. (Commerce)	Dr. C. B. Wright	M
Howard Payne Coll. (Brownwood)	Dr. Leonard R. Daniel	B C M P
Huston-Tillotson Coll. (Austin)	Prof. J. H. Morton	B C M
#Univ. of Houston	Mr. Herbert H. Curry	M Elec.
N. Texas State Coll. (Denton)	Dr. Robert C. Sherman	P
Prairie View A. & M. Coll.	Dr. E. E. O'Banion	B C M P
Southern Methodist Univ. (Dallas)	Dr. Joe P. Harris	B
S. F. Austin State Coll. (Nacogdoches)	Dr. E. L. Miller	B
A. & M. Coll. of Texas (Coll. Sta.)	Dr. James G. Potter	B C ES M P
Univ. of Texas (Austin)	Dr. Addison E. Lee	B C GS M P
Texas Christian Univ. (Ft. Worth)	Dr. E. R. Alexander	B C M P
Texas Southern Univ. (Houston)	Dr. Robert J. Terry	B C M P
Texas Technological Coll. (Lubbock)	Dr. Charles L. Riggs	M
Texas Technological Coll. (Lubbock)	Dr. Earl D. Camp	B
Texas Woman's Univ. (Denton)	Dr. Harlan C. Miller	M
Texas Woman's Univ. (Denton)	Dr. Harold T. Baker	C RB
	Utah	
Univ. of Utah (Salt Lake City)	Prof. E. Allan Davis	H M P
Univ. of Utah (Salt Lake City)	Dr. Thomas J. Parmley	B C M P
Utah State Univ. (Logan)	Dr. Neville C. Hunsaker	B M P
Utah State Univ. (Logan)	Prof. Joe Elich	M
	Vermont	
Univ. of Vermont (Burlington)	Dr. N. James Schoonmaker	M
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	Virginia	
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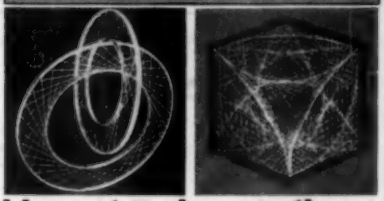

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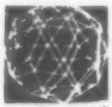

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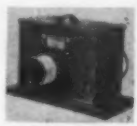

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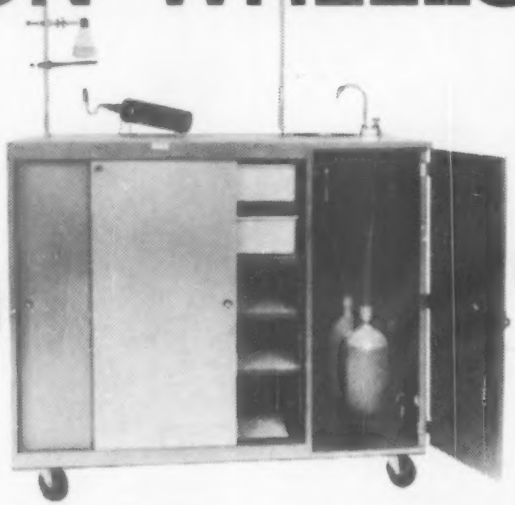

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